ETHER AND MATTER

BY

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Preface

IT is often stated that the purpose of science is to make measurements, to record observations, and to find correlations between the same. That such pursuits belong properly to the realm of science cannot be disputed, but science is not limited to purely empirical or inductive methods of investigation. Any procedure by which the facts of nature can be ascertained deserves to be recognized as a truly scientific pursuit. Modern physics is devoted largely to the use of mathematical symbols and equations, but the success of this method does not justify us in condemning the use of mechanical models as unscientific. Mechanical models are based primarily on geometry, and geometry is a branch of mathematics—a fact too often ignored by physicists. These considerations are especially pertinent in the field of atomic structure where geometric relationships must be presumed to play an important rôle, although hidden from direct view. Physicists may be correct in their general proposition that nothing is truly scientific unless it can be expressed mathematically, but it is the writer's contention that no system of atomic structure is truly scientific unless it can be expressed geometrically by pictures and diagrams—"structure" by its very definition being something which must have geometric form.

There has been much philosophical argument over whether the external physical world really exists, and whether the term "physical reality" has any meaning. If we adopt the idealistic view of Bishop Berkeley and Immanuel Kant that matter does not exist of its own accord but is only a creation of the mind, then the primary purpose of theoretical physics would not be to ascertain any unknown facts, but rather to find the clearest and most satisfactory symbolic representation of the known facts. This is the attitude taken by most of the leading physicists of today, and nearly all the recent books on quantum mechanics and atomic structure are

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couched in such language that it is impossible to tell where the world of physical reality ends and where the world of mathematical fancy begins. If we ask any exponent of "the new physics" whether the electrons actually travel in orbits about the atoms, we will probably get a lesson in jesuitism for a reply, but never any direct answer of "yes" or "no".

On the other hand if we adopt the materialistic view of Thales, Descartes, and a host of other ancient and modern writers that matter does exist of its own accord, then the primary purpose of theoretical physics would be to ascertain the true facts of nature, regardless of whether or not they will readily lend themselves to symbolic representation or mathematical treatment. For example in the case of atomic structure the vortex atom with its complex internal circulation of ether currents is more difficult to deal with symbolically in mathematical equations than the Bohr atom with its planetary electrons traveling in a grooved ether. This drawback to the vortex atom theory was recognized by A. A. Michelson when he wrote that

> The mathematics of the subject is unfortunately very difficult, and this seems to be one of the principal reasons for the slow progress made in the theory. ("Light Waves and their Uses", p. 162.)

If however we are in quest of the true facts of nature, then we cannot be concerned over whether or not the facts will be to our liking.

The present book takes the materialistic viewpoint for granted and proceeds with the assumption that the external physical world really exists. The vortex atom structures herein presented purport to be at least approximately true representations of what actually exists in nature, and not merely convenient mathematical or geometric fictions. This is more than can be conscientiously claimed for the Rutherford-Bohr atom.

The last chapter in which mind and consciousness are discussed will probably not meet with the approval of the religionists who would prefer to have everything of a spiritual nature remain shrouded in mystery and enveloped

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in an atmosphere of supernaturalism. The writer is not attempting to dispute the claims of the religionists that the activities of mind and consciousness fall within the realm of religion, but in his capacity as a student of science the writer does maintain that mind, consciousness, and all related subjects such as morals and ethics also fall properly within the realm of science. If scientists shall not have the privilege of deciding what shall be included within the realm of science, then why should religionists have the privilege of deciding what shall be included within the realm of religion? Whether the human mind is merely the subjective aspect of the living organism or is a separate soul-like entity which survives after death, and what the relation of the mind or soul is to the all-pervading ether, are questions which not only may be, but must be considered in any thoroughgoing treatise on ether and matter. The fact that the complex physico-chemical processes which give rise to mental activity are not yet as completely understood as some of the simpler mechanical processes is no reason for excluding these more complex and less understood processes from the field of science, because as Herbert Dingle tells us,

> It is not fair to insist on a rational explanation of easy things and fall back on supernaturalism for the difficult ones. If we bring in supernatural agencies at one point we may as well bring them in at all points, and save ourselves the trouble of constructing a trivial man-made rational order. (*NATURE,* June 17, 1944, p. 733.)

Although the relation of mind and consciousness to the ether has been discussed in the last chapter of this book, there has not been anything said about the relation of God to the ether. The reason for this discrimination is that we all understand what is meant by mind and consciousness, but there is no unanimity of opinion as to what is meant by "God" or how that term should be defined. To say that God is "a spiritual being" does not mean much unless we first accurately define both "spiritual" and "being". Religionists have given us definitions of God ranging all the way from the ultimate goal of human perfection in the case of a

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personal God, to mere law of nature in the case of a non-personal God. If the God under consideration is of the personal variety, then the subject has been sufficiently dealt with in the last chapter of this book because everything that was said with reference to the human mind would also be applicable to a personal God. On the other hand if the God under consideration is non-personal so as to be equivalent to mere law of nature, then the subject has also been sufficiently dealt with throughout the various chapters of this book.

There are also some who have attempted to define God as the "First Cause", but that is just another way of saying that the ether is God, the ether having been formulated in such a manner as to make it the first cause of everything. If it be argued that the ether itself must have been created originally by some God, then to be consistent it would also have to be argued that this first-mentioned God must himself have been produced by some older God, and so on *ad infinitum*. On the other hand if it be argued that a God may be eternal, then it could also be argued with equal propriety that the ether itself may be eternal. It is, in fact, the writer's opinion that the ether has actually existed from eternity and never was "created".

There is however one serious objection to any interpretation of the ether as God, and that is that the historical meaning of the word "God" should not be completely ignored. The God of past history (who is still being worshiped in all the churches of today) was definitely a personal if not an anthropomorphic God. People do not say prayers to the laws of physics or worship the principles of chemistry. Any interpretation of the ether or natural law as "God" can therefore only lead to confusion.

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THE universe, containing all that exists, has been created neither by a God nor by a man, but has always existed and will ever remain a vivifying fire, being kindled and extinguished according to definite laws. (Heraclitus of Ephesus, 540—475 B.C.)

MATTER is not, as the countless followers and adherents of that idea assert, dead, unquickened, and lifeless, but on the contrary is full of stirring life, and not an atom of it is without motion, but in constant uninterrupted movement and activity. Nor is matter, as so many assert, amorphous, but on the contrary, form, no less than motion, is its eternal, inalienable attribute. Nor is matter gross, as simple philosophers often call it, but on the contrary, so indefinitely fine and complicated in its composition as to surpass all our conceptions. . . . It is not without feeling, but is full of the most acute sensibility in the creatures it brings forth; nor, lastly, is it devoid of spirit or thought, but on the contrary, developes in the organs destined thereto by the peculiar kind of delicacy of their composition, the highest mental potencies known to us. What we call life, sensibility, organization, and thought are only the peculiar and higher tendencies and activities of matter, acquired in the course of many millions of years by well-known natural processes, and which in certain organisms or combinations result in the self-consciousness of matter. Wherefore also matter is not unconscious, as is often proclaimed with false pathos, but in its gradual earthly and organic process of development it exhibits all the cogitable degrees of consciousness from the lowest to the highest! (Ludwig Buechner, *Force and Matter,* 1884.)

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The Hypothesis of a Hydromechanical Ether

IT is generally asserted that science can reveal to us only group structure, but can give us no information as to any ultimate reality behind such group structure. It is not apparent, however, how there could even be any group structure unless there is something that is being grouped—some substrate which is itself devoid of structure, but which nevertheless has real existence. This ultimate substrate was the *materia prima* of the scholastics, and is today known as the "ether", its various forms of motion being the modern interpretation of scholastic "form".

There has been much argument as to whether the ether really exists, but the definiteness of the velocity of light and the ability of light to travel at all are strong arguments if not conclusive proof for the existence of an ether. The real disagreement is probably not so much on the existence of an ether, as on its constitution and properties. Does the ether have mass, inertia, viscosity, compressibility, or any of the other properties that are found in ordinary matter, or is it something more abstract—something in the nature of mind or consciousness? The existence of some sort of an ether is a logical necessity, but whether it is a substance or something too abstract for us to visualize will have to be left for further consideration.

If there were no ether of any sort, magnets and electric charges could not exert any magnetic or electric forces at a distance, nor could celestial bodies act gravitationally upon one another. To attribute gravitation to a curvature of space is an evasion rather than an explanation. Curved space has no more explanatory value than twisted time. It is only on the basis of a hydromechanical ether and Euclidean geometry that we can hope to explain the fundamental forces of nature. Under Einsteinian relativity no such ex-

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planation will ever be possible because as Einstein himself admits, the modern relativity theory does not permit the ether to be visualized as a system existing in space and time:

> Der Äther darf nicht aus durch die Zeit verfolgbaren Teilen bestehen; der Bewegungsbegriff darf auf ihn nicht angewendet werden. (*Äther und Relativitäts-Theorie,* p. 15, 1920.)

This assertion of Einstein is so preposterous that it should not be accepted unless the experimental proof of it is so conclusive as to leave no alternative. The experimental facts, however, do not justify such a conclusion. The Einsteinian relativity theory was based primarily on the negative result of the Michelson-Morley experiment, but this experiment could not have been expected to give anything but negative results. It was performed with an interferometer in a horzontal plane, and all horizontal directions are physically equivalent. It should have been performed with an interferometer in a vertical plane (rotating on a horizontal axis) so as to compare the velocity of light perpendicular to the gravitational force with the velocity in the direction of such force. It is only in the direction of the gravitational lines of force that we can expect to find any drift of the ether relative to the earth.

Another experiment that should be tried is to arrange an interferometer of approximately square form on one of the end faces of a large electromagnet as shown in Fig. 12 so as to compare the velocity of light in the direction of the solenoidal electric current with its velocity in the opposite direction.

Still another experiment that should be tried is to set up an interferometer of approximately square form and superimpose a strong electrostatic potential gradient along one of the bifurcated beams as shown in Fig. 17 so as to test for a flow of ether along electrostatic lines of force.

And still another experiment that should be tried is shown in Fig. 18 wherein a beam of plane polarized light is passed transversely and slightly to one side of an elongated electrostatic field. The advantage of this last experiment is that

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there is almost no limit to the possible length of the electrified wires which can be used, so that the sensitiveness of the experiment can be increased almost without limit.

And in addition to the above experiments, the magneto-optical experiment with a beam of plane polarized light should be repeated, but with magnets much longer than those heretofore used. With a magnetic field sufficiently long, a measurable rotation of the plane of polarization may be obtained, even without the presence of any material substance in the magnetic field.

If any one of the above experiments should be found to give positive results, it would be almost conclusive proof of the existence of an ether, because the above experiments do not depend on the presence of matter in the path of the light ray. Whenever light traverses a moving material medium, the latter imparts a fraction $(1-1/\mu^2)$ of its velocity to the light where μ is the index of refraction of the medium, this fraction being known as "Fresnel's convection coefficient". Such experiments were performed by Fizeau using an interferometer with circulating water and by Sagnac using a rotating glass disk. Although positive results were obtained in these experiments, they do not prove the existence of a hydromechanical ether.

It would not be consistent with scientific caution to predict positive results for experiments which have never been tried, but regardless of what the results of the above suggested experiments may be, it is none the less unscientific to assert dogmatically that the concept of motion is not applicable to the ether when the most obvious experiments for testing such a doctrine have not yet been performed.

The ether must be a fluid rather than a solid because if it were a solid the entire world would be frozen. It cannot have compressional elasticity because it would then have to be capable of transmitting waves of longitudinal displacement which have never been found to occur therein. It is either not compressible at all, or it is infinitely compressible. By "infinitely compressible" is meant its ability to flow continually into sinks or out of sources. It must also com-

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pletely fill all space, because any voids or vacant spaces would give it at least a limited compressional elasticity. It must have inertia, because without inertia any portion of it which would happen to be in motion at any instant would immediately come to a standstill, while at the same time any stationary portion of it could start moving at random. Without inertia it would be difficult to account for radiant energy and radiant pressure, or for the finite velocity and rectilinear travel of light. Furthermore if the ether would not have inertia, it would be difficult to account for the inertia of matter if the elementary particles of matter consist of ether in motion.

Another interesting question is whether the laws of thermodynamics and the principle of conservation of enery and momentum are applicable to the ether. With their usual restricted meanings these fundamental laws and principles are applicable only to isolated material systems, but the ether is not an isolated system nor is it composed of matter. On the other hand with an ether which is random or fortuitous in its behavior it would be difficult to account for the orderly behavior of matter unless we repudiate the doctrine that matter consists of ether in motion, and no other satisfactory explanation for the existence of matter has ever been suggested.

The terms "random" and "fortuitous" are really misnomers when used in the description of physical systems. They are not descriptive of the systems themselves, but only of the relation of such systems to the observer. Thus when we say that the molecules of a gas have a random behavior or that their actions are indeterminate we do not mean that they are not governed by definite physical laws, but rather that we are not able to observe the individual molecules and make measurements thereon. Similarly our inability to measure accurately both the velocity and position of an electron does not necessarily mean that the electron does not have definite velocity and position. We can conceive of a point charge of electricity passing a certain position with a definite velocity at a particular instant, even though we

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cannot obtain such information experimentally. On the other hand if the electron be assumed to consist of a vortex in the ether and as not having any definite boundaries, then we cannot even in our imagination conceive of it as having definite velocity and position. Nevertheless it must be assumed that scientific laws and principles govern everything in nature, including the ether, and there are other methods of ascertaining such laws and principles than hand-to-mouth empiricism. Our realization that the behavior of the ether is in some respects indeterminate should therefore not discourage us from further study of the same.

Since the ether does transmit light and electric waves of transverse displacement it must have shear elasticity, notwithstanding its ability to flow. These two properties are not mutually exclusive. The shear elasticity of the ether has been designated as "quasifriction" or "idealized viscosity" by Hermann Fricke in Germany who has been the leading exponent of the hydromechanical ether theory during the many years while theoretical physics remained subservient to Einsteinian relativity. In his astrophysical theory correlating temperature with gravitational force, Fricke assumed that the ether possesses a property analogous to friction by virtue of which not its energy but it direction of flow is affected—a concept which was later adopted by the writer as the basis for the new vortex theory of the atom. This quasifrictional principle was also used by Sir George Stokes in his explanation of the Michelson-Morley experiment, although he later reluctantly and perhaps erroneously abandoned his explanation.

Ever since the time of Stokes, theoretical physics has been so completely dominated by Einsteinian relativity that there have been only a few isolated physicists who have dared to appear openly in favor of the hydromechanical ether theory. Foremost among them have been A. A. Michelson (*Light Waves and their Uses*), O. Wiener (*PHYS. ZEIT.* 1924, pp. 552-559), O. C. Hilgenberg (*Über Gravitation, Trombben, und Wellen,* 1931), L. Zehnder (*Lecture before the Scientific Meeting at Stuttgart,* 1935), H. E. Ives

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(*SCIENCE, 91,* 2352, pp. 79-84, 1940), and Hermann Fricke who has already been mentioned. The present situation has been tersely summarized by Fricke in an unpublished manuscript in which he stated:

> Instead of the ether we now have formulas and equations according to which some stars are millions of times more dense and others millions of times less dense than the sun, although composed of the same chemical elements. We are now supposed to be able to ascertain (via mathematics) the diameter of the entire world, and also the number of protons and electrons in it. And finally we are supposed to be able to calculate the exact time when the world (including space and time themselves) began with the explosion of *a point!* As to all this, the 20th century physicist may harangue as much as he pleases. All of this is accepted as well-nigh certain. It is only the mechanics of the ether and the vortex atom theory which he may not write about or take up for serious study—*that* is anathema.

If there is anyone who is qualified to say whether the Michelson-Morley experiment has disproved the existence of an ether, it should be A. A. Michelson himself, and he has never come to any such a conclusion. On the contrary, Michelson has always vigorously defended the dynamic ether and vortex atom theory, and has emphatically told us that

> . . . all the phenomena of the physical universe are only different manifestations of the various modes of motion of one all-pervading substance—the ether. (*Light Waves and their Uses,* p. 162, 1903.)

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Classical *Versus* Einsteinian Relativity

THERE have been repeated attempts to demonstrate the existence of an ether by means of the Michelson-Morley experiment, first performed in 1885, but the results have always been negative or approximately so. If the earth moves through a stationary ether, then it should take light a longer time to travel back and forth in the direction of the earth's motion through the ether than in a direction perpendicular thereto. It may appear at first glance that whatever time would be lost by light waves travelling against the drift of the ether would be gained while travelling with the ether during their return trip, but this is not true. Suppose a boat can be rowed three miles an hour, and an attempt be made to go to a place downstream and back on a river which flows three miles an hour. The boat would get there in half the time, but would never get back.

The negative result of the Michelson-Morley experiment would be completely accounted for on the basis of corpuscular or emission theories of light because the observed velocity of light would then be the vector sum of the velocity with which it is emitted, and the velocity of the source. Astronomical evidence, however, is against such an assumption. Binary stars, for example, would not be observed to obey Kepler's laws, as they actually do, if the light from them partook of the motion of the source.

Today physicists usually account for the negative result of the Michelson-Morley experiment either on the basis of the Lorentz-Fitzgerald contraction formula, or on the basis of Einstein's special theory of relativity. According to the Lorentz-Fitzgerald theory, the absence of an observed ether drift is to be attributed to a contraction of the interferometer in the direction of its movement through the ether, which however has no explanatory value as long as the contraction itself is not explained. Einstein's equations of special relativity, which are based on the assumption that the

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velocity of light remains constant regardless of the relative movement of the observer and the source of radiation, are essentially nothing more than paraphrased versions of the Lorentz-Fitzgerald contraction formula $(1-v^2/c^2)^{\frac{1}{2}}$, and the latter was derived on the *assumption* that the velocity of light remains constant. This was clearly recognized by Einstein when he said:

> Of course this [constant velocity of light] is not surprising, since the equations of the Lorentz transformation were derived conformably to this point of view. (*Relativity*, p. 34.)

Regardless of whether the velocity of light is actually constant, it is rendered constant in the Einsteinian equations by the use of variable units of measurement. It is therefore not surprising that the equations of special relativity have successfully met all the so-called "experimental tests", because they are in substance nothing more than mathematical trueisms, and any violation of a mathematical trueism is unthinkable.

If the velocity of light were actually constant regardless of the relative movement of the observer and the source, then the question would immediately arise as to why we do not meet with a similar paradox in experiments with sound. The Einsteinian relativists have not yet given a satisfactory answer to this question, but nevertheless they tell us that Einsteinian relativity is no longer argued about by the physicists of today, but is actually used by them in their work. The only part of Einstein's special relativity theory that is used today for practical purposes is the Lorentz-Fitzgerald contraction formula, and that was not originated by Einstein. Experimental verification of Einstein's general theory of relativity has been claimed on the basis of the progression of the perihelion of Mercury, the bending of starlight while passing close by the edge of the sun, and the gravitational red shift. The effects actually observed in each case, however, are very minute, being almost at the limit of accuracy of experimental measurements, and as O. C. Hilgenberg has explained in detail in his recently published booklets, the

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observed effects can be accounted for under the hydro-mechanical ether theory as well as, and even better than under Einsteinian relativity.

Instead of clarifying the concept of relativity, Einstein's interpretation thereof has only introduced confusion because as soon as we tamper with the concepts of space and time themselves, we are no longer in the realm of science. Physical concepts can be understood only to the extent to which they can be visualized against the background of Eucidean space and Newtonian time, and such visualization of Einstein's second postulate is impossible. The use of variable units for the measurement of space and time in Einsteinian fashion leads to a confusion of the chronological order of events and a misunderstanding of the relationship of cause to effect. Such misunderstandings, says James Mackaye,

> inevitably arise from the attempt to ignore mechanisms and models and accept as a guide 'some mathematical expression . . . which cannot be further analyzed.' This process, though recommended by Eddington and various other modern physicists, is too blind to be safe. (*JOURNAL OF THE FRANKLIN INSTITUTE,* Sept., 1934, pp. 357-359.)

Sir Oliver Lodge has likewise expressed his disapproval of the Einsteinian relativity theory when he said in a communication to the British Association early in 1921:

> Especially do I attack that proposition which asserts that to every observer the velocity of light will not only be constant in reality, but will also superficially appear constant even when he ignores his own motion through the light-conveying medium—a proposition or postulate or axiom which has been shown to lead to curious and, as I think, illegitimate complications, threatening to land physicists in regions to which they have no right to enter, and tempting them to interfere with metaphysical abstractions beyond their proper ken. . .
>
> [The special principle of relativity] is a contradictory proposition. Given the constancy of the real velocity of light—if an observer travel to meet it, it must appear to arrive more quickly than if he travel away from it, provided he has any means of making the observation at all. . .
>
> A mathematical doctrine of [special] relativity may be based upon this experimental result [the to-and-fro journey of a beam of light], and may be convenient for reasoning purposes, but no such doctrine

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is required by the facts. The facts are patient of the doctrine; they do not compel it, nor do they justify it. Why, then, proceed to build up on an equation an elaborate metaphysical structure?

The correct explanation for the Michelson-Morley experiment seems to have been given by Sir George Stokes who assumed that the ether in the vicinity of the earth is carried along with the earth, as we would expect it to be if it possesses viscosity or quasifriction. Stokes' theory has been discarded by physicists in favor of Einsteinian relativity because it was said to be contradicted by astronomical aberration; but subsequent and more thorough studies have shown that astronomical aberration does not in any manner contradict Stokes' theory. (H. Fricke, *Weltätherforschung*, pp. 12, 82, & 115, 1939; and L. Zehnder, *ASTRONOM, NACHR.*, 1921.)

Since the Michelson-Morley experiment has always been performed with apparatus rotating on a vertical axis, it has not disproved the existence of ether currents flowing vertically in the direction of the earth's gravitational field. If such vertically flowing ether currents exist, then it should be possible to detect them with an interferometer mounted for rotation on a horizontal axis so that either one of the beams can be positioned vertically and the other one horizontally. Preparations for carrying out such an experiment have been made by O. C. Hilgenberg in Germany, but his plans were interrupted by the war. According to Hilgenberg's calculations, the ether at the surface of the earth should have a vertical velocity of 2,074 kilometers per second. (O. C. Hilgenberg, *Über Strömungsversuche mit Senken und Quellen, die das Wesen der Schwerkraft grundlegend erklären*, 1939.)

Those who wish to make a detailed study of the dynamic ether theory in its physical and astronomical applications, and of the mathematical development thereof with special reference to problems of relativity, cannot do better than to read this 1939 booklet of Hilgenberg, and also his 1931 booklet *Über Gravitation, Trombe, und Wellen in beweg-*

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ten Medien, and his 1933 booklet *Uber den Magnus-Effekt und seine Umkehrung.* A complete translation of these works cannot be presented here, but some of the pertinent portions thereof have been collected and the substance thereof will be included in this and subsequent chapters.

In the interests of clarity, and also because the formulas to be derived will be used further on, we shall begin with fundamental principles by first investigating a simple problem of motion in which the classical principle of relativity of motion will be made use of in a thorough-going manner.

In dealing with the Doppler effect and the closely related phenomenon of aberration it is customary to deal with only two systems—the source of light S and the observer O—but in our present treatment we shall introduce as a third system the ether or medium M in which the light waves are transmitted. The movements of these three systems relative to one another can be clearly visualized if we coördinate them relative to a fixed background of absolute space as a fourth system. The intrinsic nature of the waves is only of secondary importance, and the formulas to be derived will be valid not only for light waves but also for sound waves, water waves, etc. Assuming that the wave transmitting medium is homogeneous and that when it moves it does so in its entirety relative to absolute space, we arrive at the following tabular coördination of the velocity s of the source of radiation, the velocity o of the observer, and the velocity m of the medium, the 2^3 possible combinations being determined by which of the velocities are equal to zero:

TABLE I

1	2	3	4	5	6	7	8
m_0	m_0	m_0	m	m	m	m_0	m
s_0	s_0	s	s_0	s	s_0	s	s
o_0	o	o_0	o_0	o_0	o	o	o

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The following symbols will be used:

- c the velocity of the waves sent into the medium;
- f their frequency, with reference to the body from which they are sent;
- f' their frequency, as measured by the observer;
- a the angle of aberration, by which S, when observed from O, appears to be laterally displaced;
- d the actual distance between O and S;
- d' the distance by which S, as observed from O, appears either to be displaced further away in the direction OS, or to be brought closer to the observer.

Cases 2, 3, and 4 in which only one of the three systems is in motion are especially interesting, and the differences between these three cases are not merely relative. The differences between 2 and 5, 3 and 6, and 4 and 7 are however only relative if those velocities which are not equal to zero are of equal magnitude and opposite in direction.

In cases 2 and 3 the observer will encounter the phenomenon of aberration consisting of a lateral displacement of the source of radiation, and also the Doppler effect consisting of a change of frequency. Most physics textbooks do not give adequate consideration to the apparent displacement of the source of light in the direction of the light ray, which will occur in cases 3 and 4.

We shall consider successively cases 2, 3, and 4 of Table I, and especially the various cases subordinate thereto which depend on whether the movement which gives rise to the Doppler effect, or to an apparent displacement of the source of light, is parallel to the direction OS or perpendicular thereto.

It will be assumed that the wave velocity c relative to the medium in which the waves travel is independent of the movement of the source S, as can be observed in the case of water waves, and which according to de Sitter, (*PHYS. ZS.*, *14*, 429 and 1267, 1913,) is also true for light waves. The waves that have been sent out from a moving source of

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radiation will then be spread out as spherical wave fronts concentric with their original source.

In case 2 the source S and the medium M in which the waves travel are absolutely at rest, while the observer O is moving with a velocity o. The following conditions may exist:

(a) The vector o is in the direction from S to O;

(b) The vector o is in the direction from O to S;

(c) The vector o is in a direction perpendicular to OS.

(a) o is directed from S to O. At the time when the first wave reaches O, the second wave will be at a distance c/f from O. We are now confronted with the old problem of Achilles and the turtle in ascertaining the time t_w required for the second wave moving with a velocity c to overtake the observer O, who is himself receding with a velocity o and is initially at a distance c/f from the second wave. We now have:

$$ct_w = ot_w + c/f,$$

$$t_w = c/f(c-o) = 1/f',$$

$$f' = \frac{c-o}{c} f$$

It will be seen that the frequency f' as observed by O is smaller than the actual frequency f. There will be neither aberration nor an apparent displacement of the source, so that the actual location of S and its location as observed by O will coincide. This will be readily understood if we bear in mind that the amplitude of the emitted waves decreases as they spread out in the medium. In the present case the decrease in amplitude depends on the actual distance from O to S.

(b) o is directed from O to S. By making an appropriate alteration in the above calculations, we obtain:

$$f' = \frac{c+o}{c} f$$

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Here also the actual location of S coincides with its location as observed by O.

(c) o is perpendicular to OS. An observer at O does not detect any change of frequency, but rather an aberration or lateral displacement of S. For the sake of clarity this condition will be considered with reference to case 5, which differs only relatively from case 2. O will then be absolutely at rest, while M moves with a velocity $m = -o$ (in case 2), and S is stationary relative to M. We shall consider the situation at the instant when O is closest to S and is encountered by a wave crest previously emitted from S.

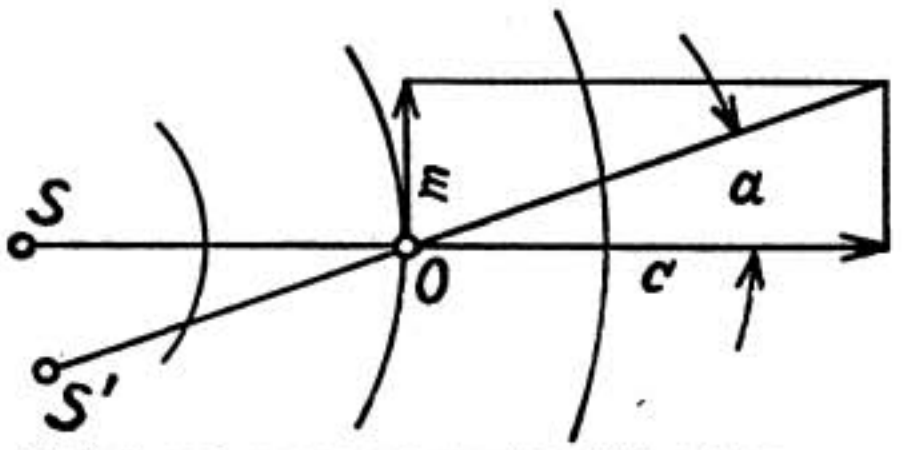

Fig. 1. Medium and source are moving with a transverse velocity m relative to a stationary observer at O.

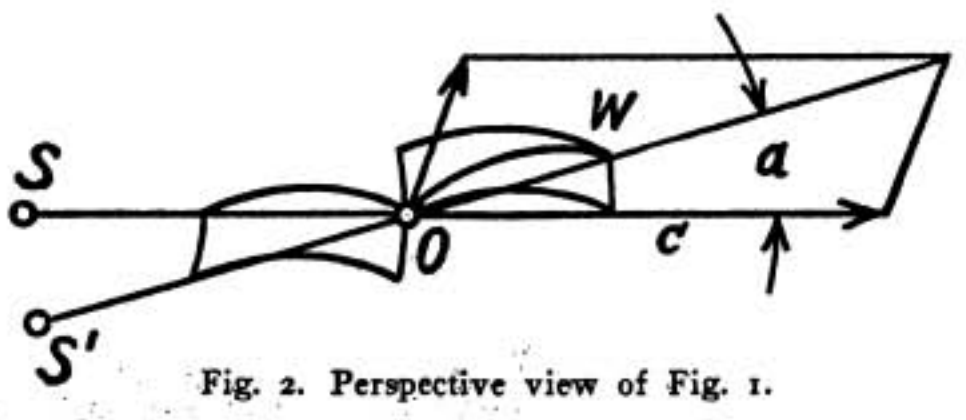

Fig. 2. Perspective view of Fig. 1.

The wave crest, which is partially represented in Fig. 1, has two velocity components, namely c in the direction SO and m (equivalent to $-o$) perpendicular to SO. This is more clearly shown in the perspective view in Fig. 2. When the wave crest, namely half a wave, has moved past O, then the rectilinearly represented wave element, which erstwhile arrived at O, will have moved to W. An observer at O will

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therefore reach the conclusion that the wave came in the direction $S'O$. The angle of aberration a will then be determined by the equation:

$$\tan a = m/c.$$

It will be readily seen that the apparent distance of S is equal to its actual distance.

The relationships of case 5 are readily applicable to case 2. As a practical example we may consider the movement of a surf rider as he is drawn in along the shore. If he closes his eyes he will get the impression that the water waves strike him, not sidewise, but obliquely from the front.

In case 3 the observer O and the medium M are absolutely at rest, while the source of radiation S moves with a velocity s. Three subordinate cases will again be considered:

(a) The vector s lies in the direction from O to S;

(b) The vector s lies in the direction from S to O;

(c) The vector s is perpendicular to OS.

(a) s is directed from O to S. At the instant when a wave is sent out, S will be at S_0. During the first oscillation sent out from S, which occupies a time $1/f$, the source S will have moved through a path s/f to S_1, whereby every point between S_0 and S_1 will have become the center of a spherical wave in such a manner that a certain displacement, as indicated in Fig. 3, will spread out from every such point with a velocity c. A displacement at S_1 will be sent out later than a displacement S_0 by an interval of time $1/f$, and requires a time s/cf to arrive at S_0, that is, it requires a time

$$t_w = 1/f + s/cf = (c+s)/cf$$

for the point S_0 to change from its state of vibration when the first wave is emitted to the corresponding state of vibration of the second wave. The wave train from S_0 to S_1 which arrives at O has a frequency

$$f' = 1/t_w = cf/(c+s).$$

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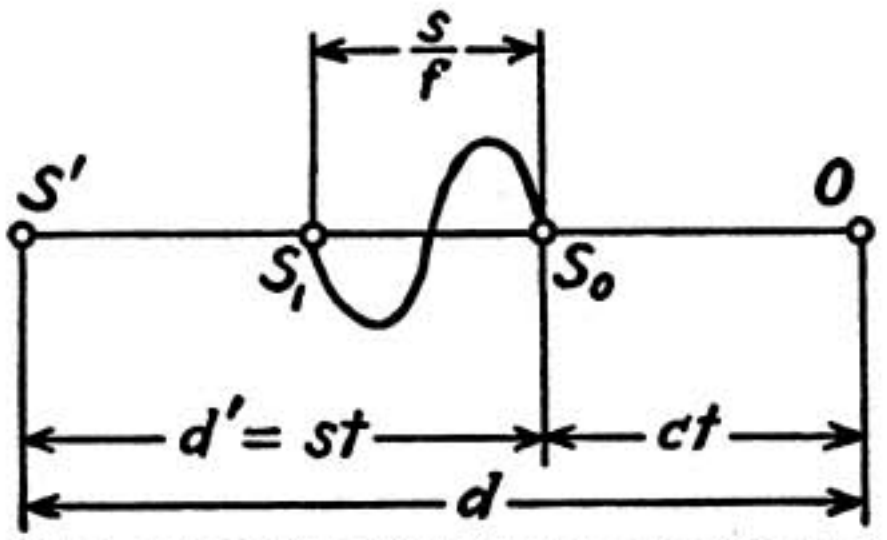

Fig. 3. Source S is moving away from the observer O.

During the time t which transpires while the first wave sent out from S_0 moves to O, the source S will have moved a distance $st=d'$ to S'. The actual distance d between O and S at the time when the first wave arrives at O is therefore OS'. The distance ct is therefore equal to $d-d'$, and we have:

$$d'=sd/(c+s).$$

The source of radiation will therefore appear to the observer O as being closer than it actually is, by a distance d'. These derivations would be more complicated if a point adjacent the observer O were to be used as the center of reference.

(b) s is directed from S to O. We then have:

$$f'=cf/(c-s)$$
$$\text{and} \quad d'=sd/(c-s).$$

The source of radiation now appears further away from O than it actually is..

(c) s is perpendicular to OS. The source S will be considered at the instant when it is at the point S' (Fig. 4) closest to the observer O. At this instant the spherical wave which was emitted from S_0, where S was located prior to the expiration of the time t, will have traveled the distance $S_0O=ct$. An observer at O will therefore see the source displaced by an angle a from its actual position, and further

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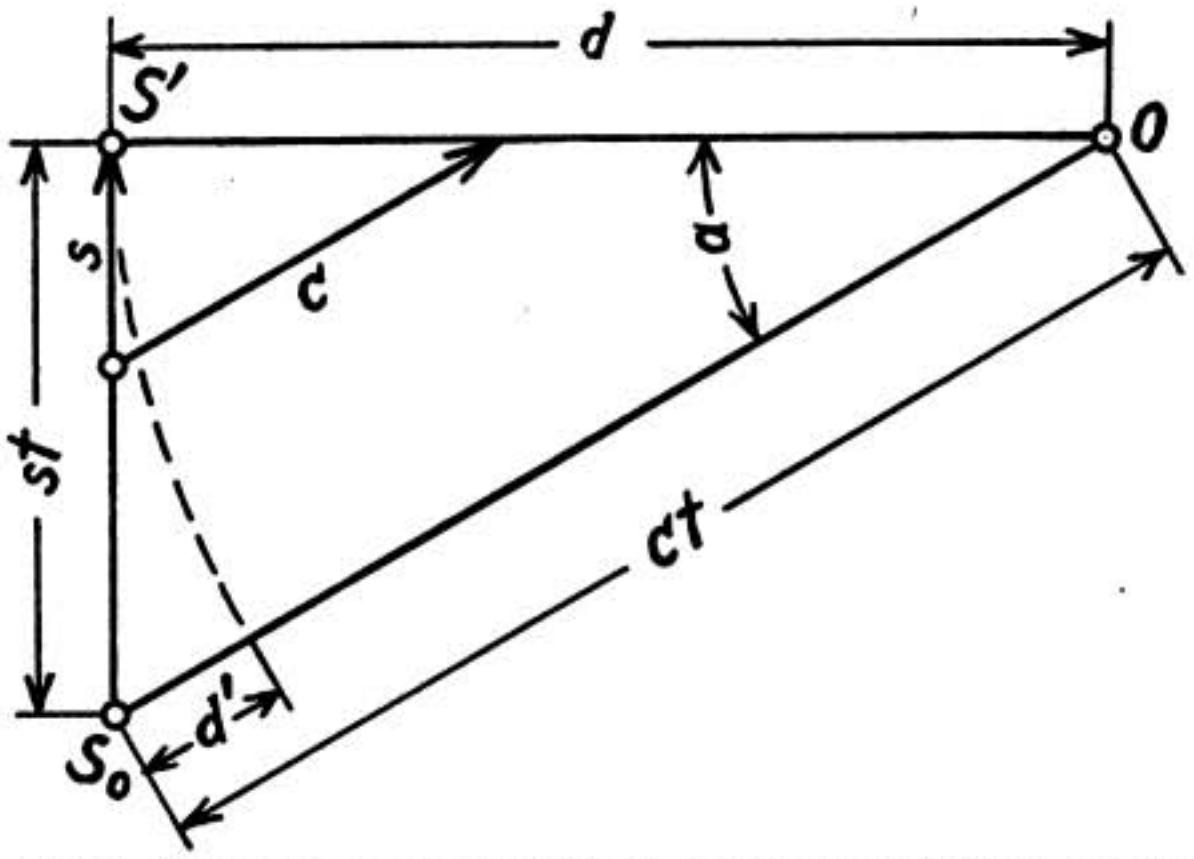

Fig. 4. Source is moving with a transverse velocity s relative to a stationary medium and a stationary observer.

away by a distance d' than it actually is. An increase of frequency will also be observed, for the following reason:

$$\sin a = \frac{s}{c}$$

$$\tan a = \frac{s}{c} / (1 - s^2/c^2)^{1/2}$$

$$d' = d[1/(1 - s^2/c^2)^{1/2} - 1]$$

$$f' = f/(1 - s^2/c^2)^{1/2}$$

For a certain value b of the angle which s makes with the line from S to O, the observed frequency f' will be equal to the actual frequency f. This angle will be

$$b = \frac{\pi}{2} + \text{arc tan } (s/c)$$

In case 4, S and O are absolutely at rest. The transmitting medium M moves with a velocity m. It can be readily seen from what has already been explained that regardless of the direction in which M moves, there can never be a

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change of frequency or an aberrational displacement observed by O because the effect of S moving relatively to O at rest in M will exactly neutralize the effect of O moving relatively to S at rest in M. Thus there can be no change of pitch in sound from a stationary source transmitting through a wind of uniform velocity, provided there is no shifting of the wind.

The apparent displacement of S in the direction OS, which will occur in case 3 but not in case 2, will not be compensated. Fig. 5 shows for the relationship $c/m = 3$ the various magnitudes of this displacement, depending on the direction

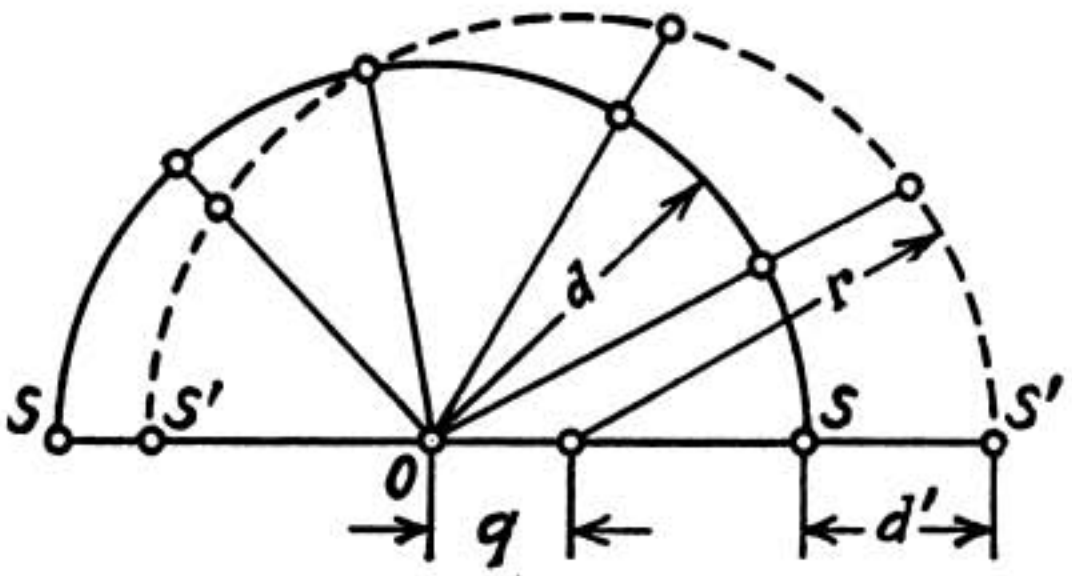

Fig. 5. Medium is moving with a velocity m in the direction SO relative to a stationary source and a stationary observer.

of the stationary vector m. S may be at any point on a circle of radius $OS = d$ with O as the center, and in any particular position of it there will be a definite angular relationship between m and OS. S' will in each case be at some point on the dotted circle of radius r and eccentricity q, so that the following relationships will exist:

$$r = d\left(1 + \frac{1}{\frac{c^2}{m^2} - 1}\right)$$

and

$$q = d\left(\frac{1}{\frac{c}{m} - \frac{m}{c}}\right)$$

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As an example of the apparent displacement of a wave-emitting body S in the direction of radiation, the spreading out of sound waves by the wind may be mentioned. It is true that the displacement of the source in this case cannot be determined by observations from points adjacent O because the direction of S will not be changed. The apparent displacement of the source in the direction of radiation will however be made known by an increase in the amplitude of the sound waves as they are being received at O.

The generalized cases 5, 6, 7, and 8 of Table I can be readily correlated with the cases that have already been discussed in detail.

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The Red Shift

WE have thus far considered only the ideal case where the ether is homogeneous and movable only as an entirety, but we shall now consider a case that is closer to the conditions that actually exist in interstellar space. We shall now assume that the light waves migrate from a stationary medium across a transition plane into a medium of the same constitution which is in uniform motion parallel to this plane, and that upon continued movement in the same direction they pass out of the moving medium and into the stationary medium again. It is generally agreed that the rays or rather the wave-front normals of the waves coming from the stationary medium will undergo refraction in the direction of motion of the medium because of the carrying along of the waves by the moving medium. If every portion of the medium be imagined to possess the attributes of an observer (or receiver) and an emitter (or sender), and if only a single stationary homogeneous medium is present, then the path and the direction of radiation (which are coincident in this case, although not always so,) can be so defined that every moving element in the wave will continue to move in the same direction in which it arrived, the ray being thus rendered rectilinear. The normal to the wave front is in this case coincident with the path and direction of the ray.

On the basis of this definition of the concepts of path and direction of radiation, the passage of a ray of light from a stationary into a moving medium will now be followed on Fig. 6. The ratio of the velocity m of the medium to the wave velocity c in the medium is there taken as $m/c = 3/4$. For the sake of clarity we shall designate all points which are at rest relative to the stationary medium by unprimed capitals, and those which are at rest relative to the moving medium by primed capitals. For simplicity we shall designate as the angle of incidence b, not the angle between the

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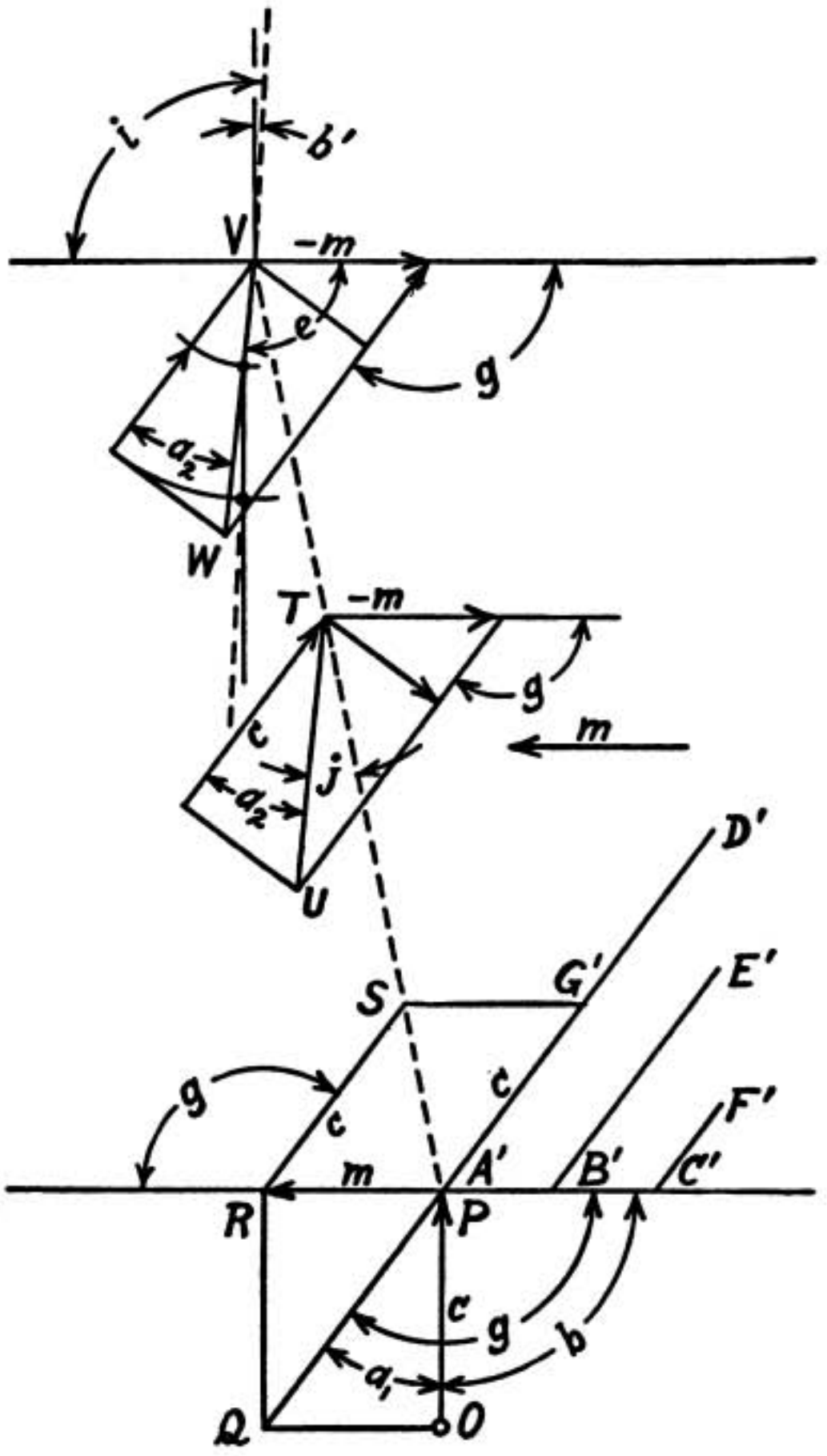

Fig. 6. A ray of light traversing a current flowing with a velocity m through a stationary medium. The incident ray is perpendicular to the direction of the current, and $m/c = 3/4$.

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incident ray and the normal to the surface of transition, but rather the angle which the ray makes with the direction of motion of the moving medium. As positive values of b will be designated all angles up to 180°. An observer at the point P on the interface PR who is at rest relative to the moving medium, and who receives a ray coming from O along the line OP perpendicular to the interface will find, because of aberration, that the ray appears to come from the point Q so as to make an angle $g=b+a_1$ with the interface, the angle of aberration being determined by $\tan a_1 = m/c$ (case 2c of Table I). Any particle A' of the moving medium will be affected in exactly the same manner. Since the particle A' is at rest relative to the moving medium, the undulatory movement which the particle received while at P will spread out as a wave impulse with a velocity c (the same as in the stationary medium) in the direction $A'D'$ in the line QP, and in a unit interval of time will travel along this line to the point G'. During this time the particle A' has moved along the path PR to the point R with a velocity m equal to that of the medium. During the same time the point G' has likewise moved to the stationary point S, that is, the wave impulse proceeding from A' has moved in the direction PS relative to the stationary medium. Other particles B' and C' of the moving medium which arrive subsequently at the point P will send out other wave impulses in directions $B'E'$ and $C'F'$ relative to the moving medium, but in a direction PS relative to the stationary medium, so that an observer at rest relative to the stationary medium who is located at any point T on the ray path PS will receive all the wave impulses from the particles A', B', C', etc. Since the stationary observed at T moves with a velocity $-m$ relative to the moving medium, he will not receive the ray from a direction parallel to $A'D'$, but because of aberration will receive it from a direction TU, the angle of aberration a_2 being determined by the relationship:

$$\tan a_2 = \frac{m \sin g}{c}$$

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The *path* of radiation and the *direction* of radiation therefore appear to the stationary observer at T to be at an angle j to each other. Furthermore such an observer will not receive the wave impulses at their original frequency f, but since the impulse emitting particles A', B', C', etc. recede from him with a velocity $m \cos g$, he will receive such impulses, in accordance with case 3 of Table I, at a diminished frequency

$$f' = \frac{cf}{c + m \cos g}$$

At the point V where the lines PS intersects the other boundary surface between the stationary and the moving media, the ray leaves the moving medium. A particle at V in the stationary medium continually receives wave impulses from a direction parallel to QP, and just as in the case of the observer at T, these waves, because of aberration, will appear to come from the direction VW parallel to TU. But they will not continue to travel in this direction in the stationary medium because in the infinitesimal region of transition between the two media the wave velocity does not remain c, but is reduced to

$$c' = c - m \cos (180° - g).$$

At the instant of transition the same conditions will exist as when a ray passes from a rarer into a denser medium, where:

$$\frac{\cos e}{\cos i} = \frac{c}{c - m \cos g},$$

e and i being the angles which the incident and refracted rays make with the plane of transition between the two media. In the stationary medium the direction of the ray is again identical with the path of the ray. The ray directions before and after traversing the moving medium make with each other an angle b', and the same diminution of frequency which occurred at T will also be observed at V.

In Fig. 7 the incident ray is shown, not at right angles to

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the moving medium, but at an oblique angle thereto. A stationary observer in the moving medium will find that the path of the ray, as well as the direction of the ray, are refracted in the *up-stream* direction, although the contrary has been stated by nearly all writers on this subject.

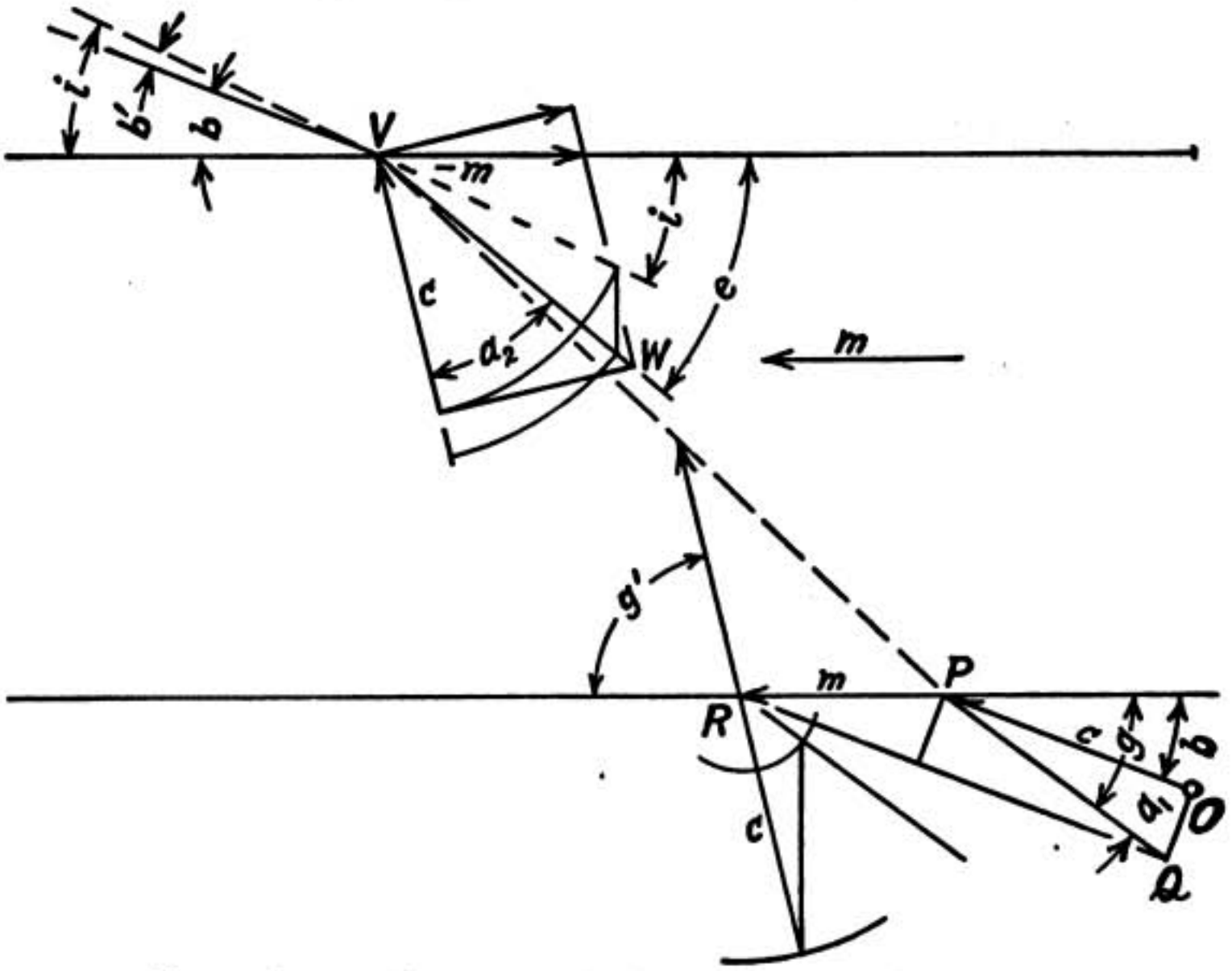

Fig. 7. Same as Fig. 6, but with the ray traversing the current at an oblique angle.

In Fig. 7 the frequency f' which will be measured by an observer who is at rest relative to the moving medium, according to case 2a of Table I, will be:

$$f' = f(c - m \cos b)/c$$

where f is the frequency at the source of radiation. The frequency f'' which will be measured by an observer at rest

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in the stationary medium after the waves have traversed the moving medium and have returned into the stationary medium will be, according to case 3a of Table I:

$$f'' = cf'/(c - m \cos g') = f(c - m \cos b)/(c - m \cos g')$$

where g' is the angle which the ray in the moving medium makes with m. Since g' for values of $m/c \leqq 1$ is always greater than b, f'' will always be less than f.

The same diminution of frequency which occurred in Fig. 6 will therefore also be observed in Fig. 7 by an observer in the stationary medium on the remote side of the moving medium. If the ray is inclined in the direction of the current, the diminution of frequency upon entering the moving medium will be greater than the increase of frequency upon leaving the same, whereas if the ray is inclined in a direction opposite to that of the current, the increase of frequency upon entering the moving medium will be less than the decrease of frequency upon leaving the same.

The following is therefore universally true for all media: Whenever a train of waves traverses a medium that has currents flowing across it, an observer who is at rest relative to the source of radiation will observe a diminution of frequency, and a simultaneous refraction of the ray in a direction opposite to the direction of the current it traverses.

In the case of light waves, this phenomenon is exhibited by the red shift of the light from distant nebulæ which is today generally interpreted as a Doppler effect, and is accepted by almost everybody as proof of the actual recession of such nebulæ. If this were a true Doppler effect, then the velocity of recession of nebulæ at a distance of 5,000 light years would be one kilometer per second. It is difficult to understand where all the energy could come from that would be necessary to give these nebulæ their outward velocity and acceleration, or why our own Milky Way should be the center of the universe. This theory is so unreasonable on the face of it that we feel compelled to look for some other explanation. It would seem more reasonable to attribute the

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red shift to ether currents in interstellar space as explained in the preceding pages, or to something analogous to the Raman or Compton effects. In either case the further a nebula is away the greater would be the regions of flowing and turbulent ether with rarified gases through which the light waves have passed.

The foregoing explanation of the red shift on the basis of interstellar ether currents was presented by O. C. Hilgenberg in 1931, in opposition to the expanding universe theory of Einstein and Lemaïtre. The vagueness and ambiguity of the Einsteinian field equations is shown by the contradictory conclusions which have been drawn therefrom, namely the finite but endless universe of A. Einstein and the expanding but massless universe of W. de Sitter, with the theories of G. Lemaïtre and A. Friedman as their final product. That there are limits to what can be learned about the facts of nature from such mathematical equations alone, was realized by de Sitter (*NATURWISSENSCHAFTEN, 19,* 369, 1931) when he remarked: "Über die mathematischen Gleichungen können wir nicht hinausgehen."

Besides the nebular red shift referred to above, there is also the gravitational red shift produced by the gravitational field of the radiating body. This can also be accounted for under the dynamic ether theory because in the neighborhood of a large gravitating body like the sun or a star there is presumably a greater turbulence of ether than in interstellar space. In answer to the Einsteinian relativists who would fain tamper with space and time themselves in order to account for the red shift, we therefore need only reply with the familiar aphorism of Lichtenberg, there being more things in heaven and on earth than are dreamed of in Einsteinian relativity.

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Gravitation

IT seems to be the prevailing opinion today that all attempts to explain the force of gravity on the basis of ether mechanics have been unsuccessful, but that a satisfactory explanation has been arrived at on the basis of curvature of space. The attempted hydromechanical explanations may have been imperfect, but they were certainly steps in the right direction. On the other hand to attribute gravitation to a curvature of space is scientifically no explanation at all, but only a metaphysical evasion. Gravitation is definitely a physical force, and therefore requires a physical explanation.

The force of gravity must act through the intervening ether, and if the ether is a fluid rather than a solid, as it obviously must be, then gravitation must be caused by a pressure of this fluid from behind rather than by a pull from in front, and such a pressure can only be caused by a flow of the ether in the direction of the gravitational force. Thus Le Sage in 1750 compared the force of gravity with the effect of a hailstorm on two circular disks held in parallelism a short distance from each other. If the storm is rather turbulent so that the hailstones strike the disks from all directions, then the two disks will be driven toward each other with a force that becomes greater as the distance between the disks becomes less. Le Sage assumed that the ether consists of "ultra-mundane corpuscles" flying about in all directions, and causing material bodies to be forced toward each other in the above manner.

Le Sage's theory did not meet with general approval because it was thought that such an action of the ether upon material bodies would cause heating thereof, but that seems to be an argument in favor of rather than against his theory, because the large celestial bodies do have surface temperatures which are proportional to the gravitational forces at their surfaces. His theory also met with disapproval because

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it was thought that an ether composed of such ultra-mundane corpuscles should be capable of being screened in a manner similar to electrostatic and magnetic forces. However, the apparent screening of electrostatic and magnetic forces is really neutralization rather than screening. There does not seem to be a single elementary force in nature which is truly screened, so why expect the force of gravity to exhibit such an unprecedented behavior?

Attempts have also been made to explain gravitation on the theory that material bodies function as ether sinks, since it can be shown experimentally that when two bodies are connected with suitable conduits so as to suck in the surrounding fluid, they will attract each other. All ether sink theories of gravitation, however, are confronted by the difficulty of explaining not only what causes such inward flow of ether, but also what happens to the ether after it is absorbed. Zenneck in coördinating the various hypotheses on the mechanical explanation of gravitation with numerous references to literature, stated as follows:

> The assumption that the ether behaves like a liquid or a gas leads to the conclusion that the ether currents must flow into the atoms of matter. According to J. Bernouilli, B. Riemann, and J. Yarkovski these ether currents carry the material bodies with them and thus cause gravitation. . . . Among the many difficulties which confront this theory, there is also the question as to what becomes of the ether which flows into these material bodies. There are only two possible answers—either the ether accumulates in them, or it disappears in the same. Bernouilli, Helm, and Yarkovski have decided in favor of the former, and Riemann in favor of the latter. (*ENZYKL. D. MATH. WISSENSCH, 5, PHYSIK* 1, 54, 1903-1921.)

Hilgenberg assumed that at least a portion of the absorbed ether is converted into matter, but the difficulty with that explanation is that the ether would still have to be compressible if it is to accumulate in any form, and furthermore the production of matter *de novo* would require much more energy than the inwardly flowing ether would possess. An infinitely compressible ether would help to solve the problem, but that would again lead to other difficulties.

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Nevertheless it seems inevitable that gravitation must be caused by a drift of the ether through the gravitating body in the direction of its acceleration, somewhat as pictured by Le Sage. If the protons and electrons of which gravitating bodies are composed were merely point charges as physicists have been assuming for nearly half a century, then it would be difficult to account for such an ether drift. On the other hand if the elementary or subatomic particles are vortices in the ether, then it would be reasonable to assume that such vortices keep the ether in a turbulent and streaming condition. The abundance of cosmic rays in the upper atmosphere seems to corroborate the theory that the ether is active and not quiescent.

A dynamically active ether will readily account for a unidirectional ether drift through the gravitating body in the direction of its acceleration. As explained elsewhere by the writer, the elementary particles of matter and electricity probably consist of dipolar vortices arranged so as to have outward polar flux and inward equatorial flux, or *vice versa*,

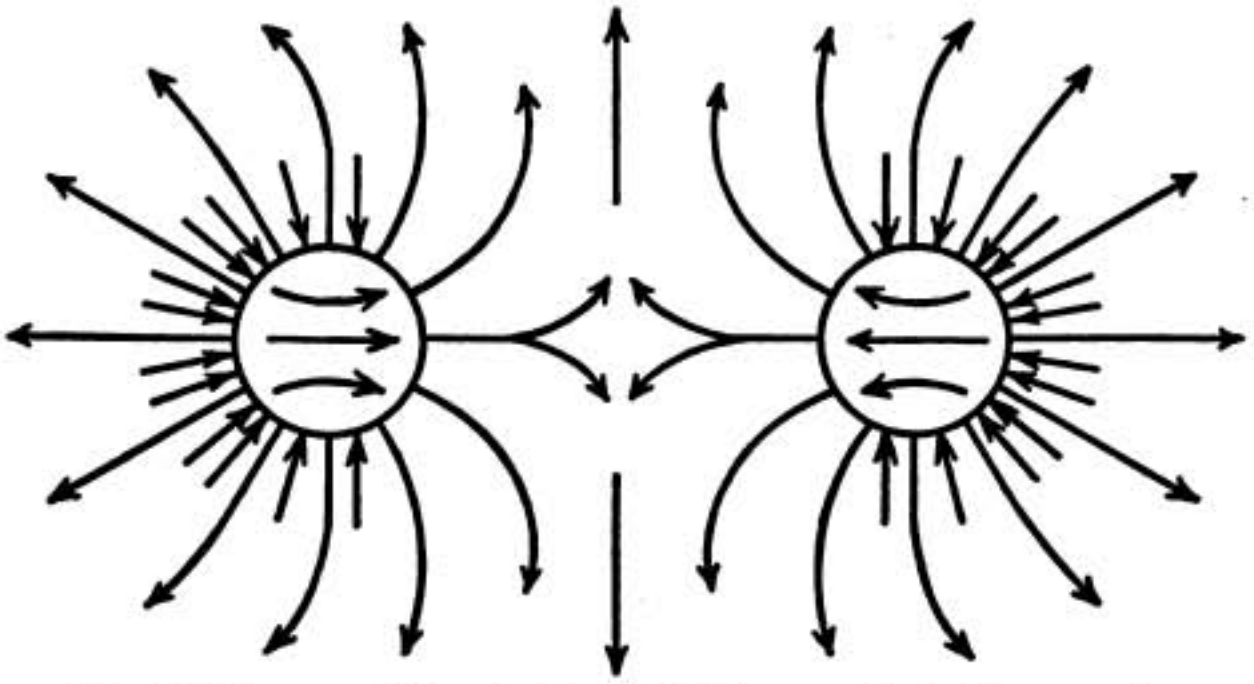

Fig. 8. Two gravitating bodies with their associated ether currents.

depending on whether they are protons or electrons. Assuming that the ether is incompressible, the total amount of ether which flows outwardly must be equal to the total

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amount of ether which flows inwardly, but the outwardly flowing currents will travel much greater distances than the inwardly flowing currents. This can be illustrated with an electric fan which will send the outwardly flowing air current a distance of ten feet or more, whereas the inwardly flowing air current cannot be felt at a distance of that many inches. Consequently when two gravitating bodies (like the earth and the sun) are at a finite distance from each other, it will be principally the outwardly flowing ether currents which will encounter each other in the space between the two bodies, and will spread out radially in all directions, eventually returning into the same bodies from the sides or from the rear. This will result in a non-uniform distribution of ether currents over the surfaces of the gravitating bodies, since more than half of the total inwardly flowing ether will enter the bodies through the sides away from each other, and less than half of it through the sides toward each other. The amount of ether that can be drawn in on the sides toward each other is also limited in each case by the presence of the other body which draws ether from the same space but in the opposite direction, whereas on the sides away from each other the two bodies can draw in ether in unlimited amounts. In Fig 8 these conditions are shown somewhat exaggerated for the sake of clarity.

The same principles apply when one of the bodies is very large and the other body very small, except that in this case the outwardly traveling ether currents of the smaller body will be deflected much more than those of the larger body, and the smaller body will therefore have a much greater acceleration. It will be seen from the foregoing that when two gravitating bodies are brought into the presence of each other, their surrounding ether currents will not remain uniformly and symmetrically distributed over their surfaces but will become organized in such a manner as to form a large double vortex with inward polar flux and outward equatorial flux, each body being at or near the center of one vortex. As is plainly shown in the diagram, this will produce an ether drift through each body in the direction of its gravitational

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acceleration toward the other body. If the atoms or subatomic particles of which each body is composed consist of vortices in the same ether, then it is reasonable to assume that they will be pushed or carried along by the ether which drifts through them.

The situation can also be presented in a somewhat different way. When two bodies are in the presence of each other, they must either attract each other, repel each other, or remain indifferent toward each other. Since the ether currents in the regions around the two bodies must be presumed to act upon each other, they will not remain symmetrical about the centers of the two bodies, and with an unsymmetrical distribution of ether currents it is not likely that the two bodies will be in equilibrium with respect to each other. They will either attract each other or repel each other. Since it can be shown experimentally that in liquids as well as in gases a sink always attracts a sink and a source always attracts a source, it seems more probable that the force resulting from such an unsymmetrical distribution of ether currents will be an attraction than that it will be a repulsion.

We shall now consider the fanciful experiment of A. Einstein for proving the identity of gravitational and inertial mass. (A. Einstein, *PHYS. ZS. 14,* 1254, 1913.) A box is suspended by a cable in free space under the influence of a gravitational field. In this box there is a person who releases a stone from his hand. The stone drops down. If the box were not in a gravitational field, but would be accelerated by the pull of the cable, then the stone, after being released, although not falling under the influence of the gravitational field, would nevertheless appear to the person in the box to behave in the same manner as when the box was suspended in the gravitational field.

The question will now be considered whether the two cases set forth above will continue to differ only relatively from each other if we bring into the field of action a third relatively moving system, namely the ether, and also a fourth system or frame of reference, namely absolute space.

If in the first case (with the stone falling in a gravitational

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field) the ether and the box are both stationary, then in the second case (with the box accelerated and the stone remaining stationary), in order to maintain the purely relative relationship, the ether would have to be put into accelerated motion together with the box. If in the second case (with the stone absolutely at rest) the ether also remains at rest, then in the first case (with the box absolutely at rest) the ether would have to fall with the stone.

Upon careful study of these two cases, which differ only relatively from each other, the last pair of suppositions appears the more probable when we take into consideration the bending of a ray of light in a gravitational field. If (as in the first pair of assumptions) the ether remains stationary relative to the box, then in the first case the person in the box might attribute the bending of a ray of light to the gravitational field; but we would get into difficulties in the second case with the box accelerated by the pull of the cable in the absence of any gravitational field, because in this latter case the person in the box would not observe any bending of a ray of light. On the other hand if (as in the second pair of assumptions) the ether moves relative to the box and with the falling stone in the direction of the gravitational field, then the person in the box (if provided with the necessary apparatus) should be able to detect a bending of a ray of light, and should also be able to detect such bending if the gravitational field were absent and the box were accelerated by the pull of the cable.

The conclusion that the ether is always at rest relative to the stone (absolutely at rest with the stone in the case of the accelerated box but descending at the same rate as the stone in the case of the box suspended in a gravitational field) is however untenable because if two stones were dropped in succession then the ether which moves in unison with the first stone could not be at rest relative to the second stone.

We shall therefore consider a third scheme and assume that a gravitational field acting upon a material body corresponds to a flow of ether through the body in the direction

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of the field. A box positioned in such a field will have a uniform ether current flowing downwardly through it. A stone held by an observer in the box will also be traversed by the ether current, and will fall if released. And a ray of light traversing the box (unless it is exactly in the direction of the ether current) will be bent. In the case of the accelerated box in the absence of a gravitational field, the box will be traversed by an ether current in a direction opposite to its acceleration. If the stone has been released just prior to the acceleration of the box, then it will not be traversed by an ether current and its position in absolute space will not change. But a ray of light traversing the box will appear to an observer in the box to be bent.

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The Constitution of the Sun and Stars

OUR study of the ether and gravitation should not be concluded without a brief consideration of the astrophysical theories of Hermann Fricke who has been sponsoring the theory of a dynamic ether with quasifrictional properties, in opposition to the relativity theory of Einstein and the quiescent ether theory of Lorentz. (H. Fricke, *Die im innern erdähnliche Sonne,* 1934; and *Weltätherforschung,* 1939.) It is Fricke's contention that the sun and stars are not hot and gaseous inside as taught by the astronomers of today, but that they are earthlike bodies covered with great depths of ocean water, and with only their outer atmospheres incandescent. According to Fricke the high surface temperatures of the sun and stars are caused by a frictional effect of the force of gravity upon the gaseous atmospheres, as for example by a flow of ether in the direction of the gravitational force, or by large numbers of cosmic ray particles being drawn in by the force of gravity.

The argument most frequently presented in opposition to Fricke's theory is that the high surface temperature of a body like the sun would soon exaporate any water in the interior. It is a well established principle of physics, however, that heat can travel only by radiation, conduction, or convection. Radiation is immediately stopped by the thinnest layers of opaque material, and therefore cannot penetrate for any distance into the sun's interior. Conduction is equally inadequate where thousands of miles of poorly conducting material have to be traversed. There remains then only convection, and the effect of convection is to produce stratification—the cooler masses sinking to lower levels while the hotter masses rise to the top. Every large gravitating body therefore acts as an automatic refrigerator, the interior being kept cool while any heated material is brought to the surface. Since there seems to be no obvious fallacy in

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Fricke's theory, his reasons will now be presented in detail as follows:

(1) The moon which is relatively small has a low surface temperature and no water. The earth which is of moderate size has a somewhat higher surface temperature and a limited amount of water. It would naturally follow therefore that the sun which is of large size should have a high surface temperature and much water.

(2) The sun has a sharply defined circular outline, which would be difficult to explain on any other basis than that there is a transition at its surface from the gaseous state to the liquid state.

(3) Sunspots plainly show that the sun is dark inside. Photographs of sunspots taken from different angles clearly show that the dark regions are below and not above the level of the luminous layer. If the interior of the sun were at a temperature of millions of degrees, then it would be contrary to all the laws of physics for the sun to be dark inside. It may be true that temperatures of several thousand degrees have been found to exist in the sunspots, but that is probably due to hot gases from higher levels of the photosphere which overlie the craters of the sunspots. The undisputed fact is that sunspots are at a lower temperature than the luminous surface, whereas if the sun were at a temperature of millions of degrees inside, then sunspots should be brilliantly incandescent.

(4) Sunspots always occur in the same portions of the sun's surface. (*SCIENCE, 92,* 309, 1940.) This is readily explainable if the sun has a solid interior, but if it were gaseous inside, then the sunspots should not be confined to any particular portion of its surface.

(5) The average density of the sun is 1.41, or only slightly greater than that of ocean water. This is just what would be expected if it consisted of a solid interior covered by a great depth of ocean water.

(6) If the heat of the sun were generated in the interior,

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then it could only be the result of the high pressures inside. Enormous pressures have been produced artificially, but no spontaneous heating effects have ever been observed.

(7) If the sun's heat is caused by gravitational action at its surface, then other celestial bodies, as for example the earth, should exhibit similar effects. In the polar regions the temperature never falls below about –67°C, which is 206° absolute. With the poor thermal conductivity of the rocks forming the surface of the earth, this residual temperature of 206° absolute would soon be radiated away during the long winter night of the polar regions if it were not being continually replenished. If it is the gravitational force of the sun which keeps up the sun's heat, then it should also be the gravitational force of the earth which keeps up the residual heat of the earth. The gravitational force at the surface of the earth being 1/28th that at the surface of the sun, the residual temperature at the surface of the earth should also be 1/28th that at the surface of the sun. And 1/28th of 5780° is about 206°.

Fricke's theory has been used with remarkable success for the calculation of the masses and densities of the fixed stars, especially those which are of the same type as our sun. On account of the great distances of all stars, they appear merely as point-sources of light, even in the most powerful telescopes. Their diameters therefore cannot be measured directly, but must be calculated on the basis of other factors. And since their densities depend on their diameters, it is obvious that we cannot ascertain their densities with any greater certainty than their diameters. How unreliable the usual methods of calculating stellar densities are will be apparent from the fact that some stars are supposed to be thousands of times more dense than any known substance, whereas others are supposed to be more attenuated than the inside of a vacuum tube. Surely these values cannot be true to fact, notwithstanding the dogmatic certainty with which they have always been announced.

On the other hand if stellar diameters and densities be

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calculated on the basis of Fricke's theory, the proportionality between surface temperatures and gravitational forces will lead to the following formulas:

$$\text{Mass} = \frac{T\ d^2}{S} \qquad \text{Density} = \frac{T}{S\ d}$$

where the mass and the density are in terms of the sun's mass and density, and the surface temperature T of the star is in terms of the surface temperature S of the sun, d being the diameter of the star in terms of sun-diameters.

Calculations of the densities of large numbers of fixed stars have been made by Fricke, and the densities have always been found to be about what would be expected if the star consisted mainly of water, or in the case of a giant star, of water vapor. Extremely high or extremely low densities never occur if the calculations are made on the basis of Fricke's theory.

One would think that after all the precepts which have been promulgated about "the scientific method," it should not be difficult to induce the scientific profession to give Fricke's theory due consideration on the basis of its merits instead of merely ignoring it. If Fricke's theory is obviously wrong, then it is the duty of those in authoritative positions to expose its fallacies, whereas if it is obviously correct, then it is their duty to publicly endorse it. And if it is not possible to come to any immediate conclusion either for or against it, then it is the duty of those in authoritative positions to present it alongside the theory of Eddington and Jeans instead of giving publicity only to the latter and thus making it appear that the gas-ball theory is the only available explanation.

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Electromagnetism

A MAGNETIC field seems so completely different from an electrostatic field that there would appear to be no relationship between the two, were it not for the fact that both have their seat or origin in the same electrified particles and that both can coexist in the same space around such particles. The electrostatic field is usually considered as a condition of stress or strain in the ether (or in free space without any ether), but the difficulty with such a concept is that a condition of stress or strain can exist only in a solid body having rigidity whereas the ether, (or free space if we prefer that term) cannot possess rigidity. If the ether is not a rigid solid then it must be a fluid, and if this fluid is incompressible then the electrostatic field can be nothing other than a state of flow or circulation therein.

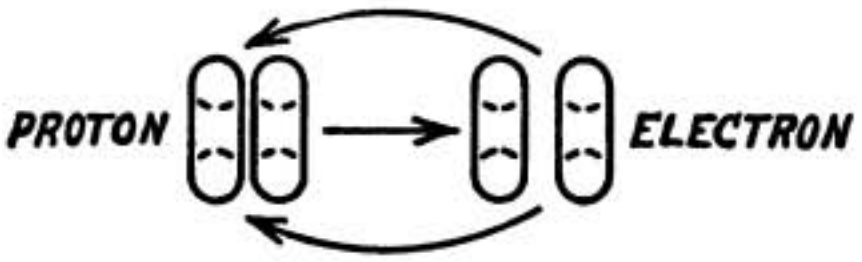

Fig. 9. The hydrogen atom with its associated ether currents.

In Fig. 9 the ether is shown as flowing in a direct line from the proton to the electron, and returning through outside paths. When a proton is in close proximity to an electron, the first question that confronts us is whether they have any orienting effect upon each other. If the ether is a viscous or quasifrictional fluid, then this question must be answered in the affirmative, and considerations of symmetry compel us to assume that the most stable configuration will be that in which the proton and the electron are in axial alinement because this is the configuration in which the symmetry is a maximum. The edge-to-edge arrangement would be next in order of symmetry, but this presents such insuperable difficulties in the building of the more complex atoms that it

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does not need to be considered seriously. The relationship of this coaxial arrangement to the magnetic field will be explained later.

The magnetic field is sometimes envisioned as a circulation of ether in circles or spirals around the electric current so that in a solenoidal winding the ether would flow out of the north pole and into the south pole. This interpretation cannot however constitute a true picture of what actually takes place because if two currents flow in the same direction in parallel wires their surrounding ether currents would then rub each other in opposite directions in the space between the wires so as to cause repulsion instead of attraction. This can be demonstrated by two parallel shafts suspended vertically in water. If they are rotated in the same direction they will repel each other. The ether therefore cannot be considered as flowing in circular or spiral paths around the current-carrying wires.

It has also been suggested that the magnetic field may consist of a flow of ether longitudinally of the wire carrying the electric current, the ether presumably being carried along by the moving electrons. This theory will explain the attraction and repulsion between parallel electric currents flowing in the same and in opposite directions respectively, but it breaks down when we try to explain why a stream of electrons repels a parallel stream of protons (in a vacuum tube) travelling in the same direction. If the magnetic field is caused by some of the surrounding ether being carried along by the moving electric charges, then it would seem that a stream of protons should be magnetically attracted to a wire carrying a current of electrons in the same direction, whereas actually they are magnetically repelled from each other. The ether therefore cannot be considered as being merely carried along by the moving electrons or protons.

These difficulties are avoided by the ether vortex theory which teaches that protons and electrons do not merely carry the adjacent ether along with them, but that they keep it in circulation between them as shown in the above diagram. If one proton and one electron produce an ether

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circulation of the kind shown in Fig. 9, then it is reasonable to assume that many protons and many electrons will produce a similar circulation, but on a larger scale. Ordinarily the protons and electrons in a copper wire are arranged at random, but when a current flows along the wire the free electrons during their movement will tend to aline themselves with their associated protons in a direction parallel to the axis of the wire, and the circulating ether currents will orient themselves accordingly. For reasons explained elsewhere, it seems more probable that the direct axial or polar flow of ether is from the protons to the electrons instead of in the reverse direction. The axial or polar flow will then be confined to the inside of the current-carrying wire, while the return flow will be principally on the outside of the wire and in the opposite direction. Two parallel wires carrying electric currents flowing in the same direction will then attract each other because, as shown in Fig. 10,

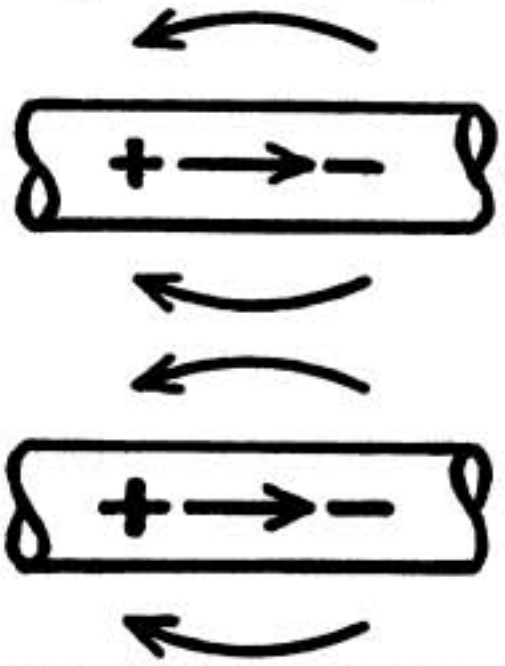

Fig. 10. Two electric currents flowing in the same direction. The arrows indicate the direction of flow of the ether. A comparison of this diagram with that of the hydrogen atom will show that there is a close relationship between the electrostatic and the magnetic field.

the external flow of ether will be in the same direction along both wires. This will also be true if in place of one of the wires we substitute a vacuum tube through which is sent a stream of protons in a direction opposite to the direction of

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travel of the electrons, because a movement of electrons in one direction will produce the same orientation of ether currents as a movement of protons in the opposite direction. It is only their relative movement that is necessary.

If the currents in the two wires are in opposite directions, the external ether flow of one wire will be in a direction opposite to that of the other wire, so that the two currents will then repel each other.

Electromagnetic induction is usually attributed either to a "cutting" of the magnetic lines of force, or to the presence of "kinks" in the electrostatic lines of force of the accelerated or retarded electrons. However convenient these concepts may be for making practical calculations, they cannot constitute the real cause of electromagnetic induction because neither magnetic nor electrostatic lines of force are physical realities. They are merely mathematical fictions, and to talk about a mathematical fiction coacting with a material particle to exert a force thereon, does not make sense.

Under the ether vortex theory when an electric current is started in a wire there will be established a return flow of ether externally of the wire in a direction opposite to the direction of movement of the electrons. When this reaches

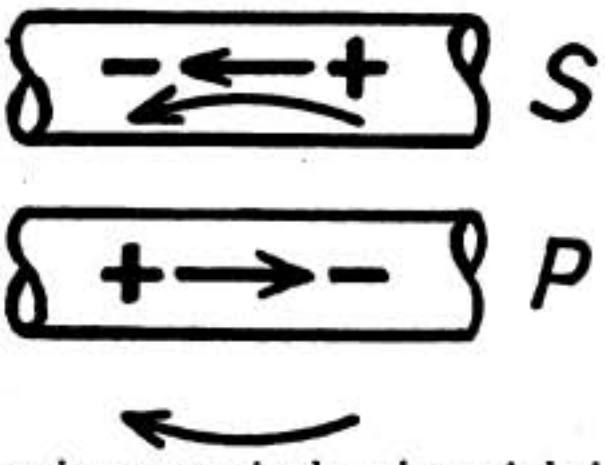

Fig. 11. An increasing current in the primary inducing a current in the secondary in the opposite direction. The arrows indicate the direction of flow of the ether.

an adjacent wire parallel thereto, it will cause the free electrons and their associated ether currents in the second wire to orient themselves in such a manner that the quasifrictional

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or viscous opposition will be a minimum. Since the protons are anchored in fixed positions, this can only be accomplished by a movement of the free electrons in the second wire in the same direction as the external ether flow of the first wire. An increasing electric current in the primary therefore induces a current in the secondary in the opposite direction.

If now the current in the primary does not increase any further but continues to flow at a constant rate, the secondary will still be in the magnetic field of the primary. There will then no longer be any actual flow of electrons or any induced electromotive force in the secondary, but the condition of electronic orientation that was previously established will continue to exist. This is evidenced by the ability of a magnetic field to cause rotation of the plane of polarization of light as it traverses a material medium.

If the current in the primary now decreases, the reverse of the above process will occur. The external flow of ether in the space around the primary will diminish, so that the free electrons in the secondary and their associated ether currents will again assume random positions. Since the protons must remain in fixed positions, this can occur only by movement of the free electrons in the reverse direction, namely in the same direction in which the electrons are moving in the primary. A decreasing electric current in the primary therefore induces a current (or electromotive force) in the secondary in the same direction.

The foregoing concept of the magnetic field is capable of direct experimental test with the apparatus shown in Fig. 12 in which the circle represents the end face of a very large electromagnet, and the curved arrows represent the direction of flow of the ether. With an interferometer arranged as shown there should be a shift of the interference fringes when the solenoidal current is turned on, provided the ether flows with sufficient velocity. The direction of the shift should be such as to indicate a flow of ether in a direction opposite to the direction of travel of the negative electrons in the solenoidal current.

There is no method known by which the velocity of the

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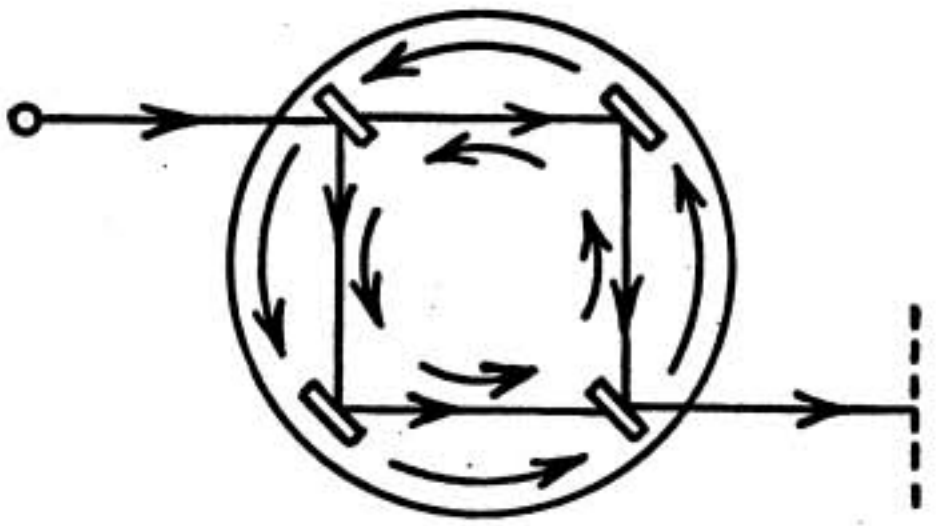

Fig. 12. An interferometer arranged on the end face of a large electromagnet.

ether in a magnetic field of given intensity can be calculated, but the fact that a magnetic field *in the absence of any solid or liquid substance* does not rotate the plane of polarization of light to a measurable extent enables us to place an upper limit on such velocity.

Whether the flow of ether in the magnetic field is actually in the direction indicated, or in the opposite direction, depends on which of the two dipolar vortices is the proton and which is the electron. For reasons which will be explained later, the one with outward polar flux has been interpreted as the proton and the one with outward equatorial flux as the electron. This conclusion seems to be corroborated by the fact that nearly all substances when placed in a magnetic field will rotate the plane of polarization of light in the direction of the solenoidal electric current, namely in a direction opposite to the direction of movement of the negative electrons. In those few cases (ferric chloride for example) where the rotation is in the reverse direction it is probably due to some peculiarity of the molecular structure.

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Theories of Atomic Structures

THE atomic theory is usually thought to have been originated by Dalton and Higgins in the early part of the nineteenth century, but actually it had its origin in ancient Greece and India. In the old Sanskrit literature of India, dating further back than 500 B. C., Kanada had formulated an atomic theory in which all atoms consisted of the same elementary particles. In Greece the atomic theory was first developed in detail by Leucippus of Miletus, Ionia, who probably derived his ideas from the more ancient Hindu writings. We have today only one fragment of the original writings of Leucippus, and in that we read the remarkably advanced doctrine that "Nothing happens without a cause, but everything with a cause and by necessity." Democritus who was a student of Leucippus wrote a book "On the Order of the Universe" in which the views of Leucippus were closely adhered to, and it is Democritus rather than Leucippus who is today generally honored as the founder of Greek atomism.

The atoms of Leucippus and Democritus differed from one another in shape and size and in the arrangements which they assumed, but they were physically indivisible. They were provided with different mechanical contrivances for attaching themselves to other atoms in definite spatial relationships, thus differing from the modern atomic theories only in the use of mechanical rather than electrical contrivances. In fact, the contrivances suggested by the ancient Greek atomists would seem to be more suitable for effecting chemical combinations than the planetary electrons of the Bohr atom.

In the textbooks of today we generally find mentioned only two theories of atomic structure—the Bohr theory and the Lewis-Langmuir theory, both of which are versions of the Rutherford nuclear theory, and both of which have been combined and reconciled (or shall we say "erased"?) by the Schroedinger wave-atom theory. The Bohr theory is beset

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with so many difficulties that it cannot be seriously considered as constituting even an approximate picture of physical reality. The main argument in favor of it has been that it furnished a physical basis for the derivation of the Balmer formula for the calculation of spectral frequencies, but it is now known that the Balmer formula can be derived on the basis of the quantum theory alone, independently of the concept of orbits. The Lewis-Langmuir theory probably has a scintilla of truth in it since it assigns the electrons to definite positions in the atoms, but like the Bohr theory it also requires a galaxy of arbitrary postulates in order to produce an operative working model of the atom.

The unsatisfactory character of the present-day theories of atomic structure has demonstrated that we cannot hope to gain a complete understanding of the structure of the atom until we have first ascertained the structures of protons, electrons, and neutrons. These subatomic particles must have physical structures, and it is inconceivable how their structures can consist of anything except stable forms of motion in the ether.

It has already been explained that the ether must be either entirely incompressible, or it must be infinitely compressible. The relationship of these two ether concepts to the various systems of atomic structure is as follows:

Incompressible ether		Infinitely compressible ether
Vortex atom	Wave atom	Source-sink atom

Any system of atomic structure which really goes down to fundamentals is classifiable under one or another of these headings, at least no other basis on which to explain the existence of atomic particles has ever been suggested. The existence of atoms is not explained by merely saying that they consist of protons, electrons, and neutrons as long as the existence of these subatomic particles themselves is not explained. The most outstanding characteristic of all elementary particles of matter is their *localized persistence of individuality,* and it is inconceivable how this can be ex-

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plained on any other basis than vortex motion, wave motion, or motion into or out of a center functioning as a sink or source.

If the ether is incompressible, then it can have only two forms of motion which are dynamically self-sustaining, namely vortex motion and wave motion. The stability of these two forms of motion is not due to any unique property of the medium, but is inherent in the form of motion itself.

An infinitely compressible ether may be able to support wave motion but cannot support vortex motion because if the ether is freely compressible then it must also be freely expansible, and any form of vortex motion would immediately become dispersed in it by centrifugal force. An infinitely compressible ether is however ideally suitable for ether sources and sinks because such an ether should be capable of flowing continually out of or into pointlike sources or sinks in accordance with Newton's first law of motion. This would account for the localized persistence of individuality of the elementary particles of matter, and would also furnish a satisfactory basis for a source-sink theory of gravitation such as that of O. C. Hilgenberg. Until the present time, however, there has not been any source-sink theory of atomic structure worked out in sufficient detail to justify its presentation here.

By the "wave atom" in the above classification is meant an atom which consists entirely of wave formations, and not atoms of other types which merely carry wave formations along with them. A vortex atom for example may be assumed to carry an array of standing waves along with it in the form of nodes and loops in the streamlines of the circulating ether, as is evidenced by electron diffraction patterns, but this is something very different from the usual concept of "wave atom".

Wave motion, although dynamically self-sustaining, is not localized in space like the elementary particles of matter and is therefore not sufficient in itself as a *basis* for atomic structure, although it may be *ancillary* thereto. The wave atom of modern physics could not exist of its own accord, but would

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have to depend on something else within it to give it shape and form, because a train of waves, either alone or in conjunction with other wave-trains, will not remain localized in space like the elementary particles of matter. Perhaps the wave atom should not have been included at all in the above classification. The very fact that we are still without any satisfactory pictures or diagrams of the supposed wave atom structures of protons, electrons, and neutrons should make us skeptical about the merits of wave motion as a *basis* for atomic structure.

What is generally known as the "wave atom" is only a sophisticated version of the Rutherford-Bohr nucleated atom. The present popularity of the nuclear theory, however, is not due to any intrinsic merits of that theory, but rather to the fact that the nuclear concept of the atom has been worked upon by the entire scientific profession for nearly half a century, whereas the modern vortex concept of the atom is only about one decade old and has never been published in such a manner as to bring it effectively to the attention of physicists and chemists. In order to correctly evaluate the relative merits of these two theories, the vortex theory should therefore not be compared with the nuclear theory of today, but rather with the nuclear theiry as it existed twenty or thirty years ago. Even that would give the nuclear theory an unfair advantage because the nuclear theory has never had to face the emotional prejudice and ridicule which the vortex theory has always been confronted with. The reason for this emotional prejudice and ridicule had been twofold: 1st because the very name "vortex atom" has always brought to mind the obsolete and unsuccessful vortex atom thery of Lord Kelvin, and 2nd because vortex rings suggest smoke rings which are usually blown for amusement rather than for serious scientific study. The scientific profession of today does not give serious consideration to the vortex theory because it is not endorsed by authorities of recognized standing, and the authorities refuse to endorse it because it is not recognized by the scientific profession. From such a vicious circle it is difficult to find a way out.

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Introduction to the Vortex Atom

IT was Rene Descartes early in the 17th century who was the first to make extensive use of the ether vortex theory for the explanation of natural phenomena. In 1690 Descartes' theory of vortices was revived by Christian Huygens in his *Discourse sur la Cause de la Pesanteur,* but after that nothing further seems to have been done with the vortex theory until 1839 when James MacCullagh in his *Essays towards a Dynamical Theory of Crystalline Reflection and Refraction* developed a type of elasticity for the ether which was wholly rotational, resisting angular deflection somewhat like a flywheel. MacCullagh's ideas were further expounded by W. J. Macquorn Rankine in 1850 (*Scientific Papers,* 1881, p. 17.) and in 1878 Clerk Maxwell commented favorably on Rankine's theory. (*Scientific Papers,* Vol. 2, p. 662.)

In the meantime the atomic theory of Dalton and Higgins had become firmly established, and it was Hermann von Helmholtz who first correlated the stability of vortex motion with the permanence of the elementary particles of matter. Helmholtz brought this to the attention of William Thom-

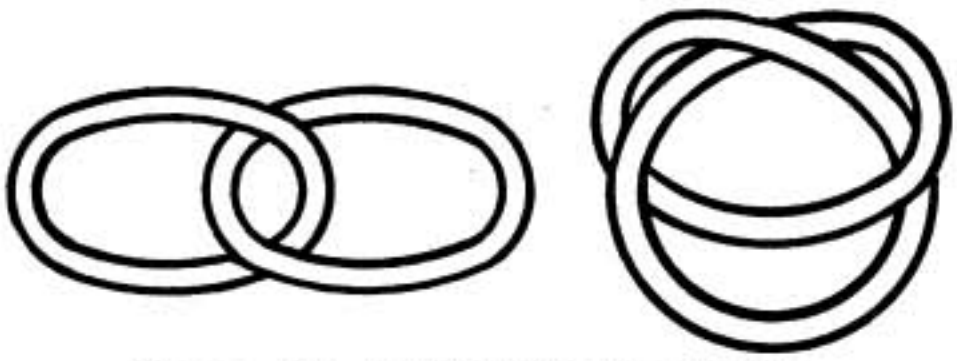

Fig. 13. 19th century vortex-atom models.

son (Lord Kelvin) who then became one of the leading exponents of the 19th century vortex-atom theory, along with Joseph Larmour, A. A. Michelson, and many others.

Nearly all physicists of the 19th century assumed that the ether is a frictionless fluid and that a vortex filament would

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not exert any effect upon its surroundings, which was really an inconsistent position for them to take since the entire classical theory of electrodynamics took the existence of an ether with viscosity for granted. The 19th century physicists attempted to account for the different chemical elements by different forms of knotting or interlinking of the vortex filaments. Such knotting or interlinking, however, will always bring adjacent filaments into such relationship that they will rub each other in transverse or opposite directions. It is only in structures formed of simple circular vortex rings where there is no internal rubbing, and the latter have accordingly been adopted by the writer as the ultimate structural units of all atomic particles.

The new vortex atom should therefore not be confused with the Kelvin vortex atom with which it has little if anything in common. It may however be regarded as a further development of the dynamic atom of Philipp Lenard which preceded the Rutherford-Bohr atom and was a competitor of the latter. The Lenard atom was based entirely on experimental evidence and did not depend on any theory. It consisted of a number of "dynamids" which were couplets of positive and negative charges of definite moment. These were distributed throughout the atom and were assumed to be so constituted that they would capture slowly-moving electrons from a stream of cathode rays, but would allow the more rapidly moving electrons to pass by uncaptured. The scattering of electrons was attributed by Lenard to close approaches of the electrons to the dynamids.

In the vortex atom of today the "dynamids" are the helium groups which are distributed throughout the atom with an abundance of vacant space between them, exactly as postulated by Lenard. These helium groups should be capable of capturing slowly moving electrons whenever one of the outermost vortex rings is knocked off from a neutral helium group so as to expose a positive charge. This capture of electrons cannot be satisfactorily explained under the nuclear theory. When cathode rays pass through an aluminum foil, there is no reason why the aluminum atoms, if

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constituted according to the nuclear theory, would capture any of the electrons, and especially not the slowly moving ones which are actually captured in greatest numbers.

The deflection of alpha particles can be explained as readily under the new vortex theory as under the nuclear theory. The experiments merely prove that all parts of the atom are *firmly bound* to a tiny central region, but do not prove that the entire mass of the atom is contained within this central region. A structural center is not necessarily a nucleus. In the new vortex atom all parts are *firmly bound* to the central helium group, although not contained within the same. These central helium groups will have the same effect as atomic nuclei when bombarded by high velocity particles. In the vortex atom, just as in the nucleated atom, abrupt deflections will be produced only when the atom is struck somewhere near its center.

Vortex rings can differ greatly in size and proportions. The size of the elementary vortex rings is probably determined by the average density of matter in the universe, but the ratio of filament diameter to ring diameter probably depends on other factors. The upper limit of this ratio is ½, but there is no theoretical lower limit. It is obvious, however, that if the vortex filament were to become indefinitely attenuated and the diameter of the vortex ring indefinitely increased, the ring would eventually become too fragile to maintain its integrity. It must therefore be assumed that the elementary vortex rings either do not have any tendency at all to change their size, or that they tend to shrink to a minimum ring diameter with a maximum filament diameter. It seems that viscous opposition from the surroundings, which always acts inwardly toward the center of the ring, would give such rings a tendency to shrink to a minimum over-all size. It is therefore thought that the elementary vortex rings either do not have any central opening at all, or one that is relatively small.

It is also possible that the elementary vortices may not be rings with definite surfaces and diameters, but rather centers of convergent and divergent flow in the ether. Nevertheless

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the conventional form of vortex ring will be used in the diagrams for the sake of clarity.

If the ether possesses a property analogous to viscosity or fluid friction, then it must be assumed that when two vortex rings come into close proximity with each other they will assume only those positions in which there is a minimum of rubbing contact and a maximum of rolling contact between them. These conditions will be satisfied if they are arranged coaxially with both of their adjacent surfaces moving either inwardly or outwardly in the equatorial plane, but not in opposite directions. The geometric possibility of two such arrangements immediately suggests a structural basis for protons and electrons.

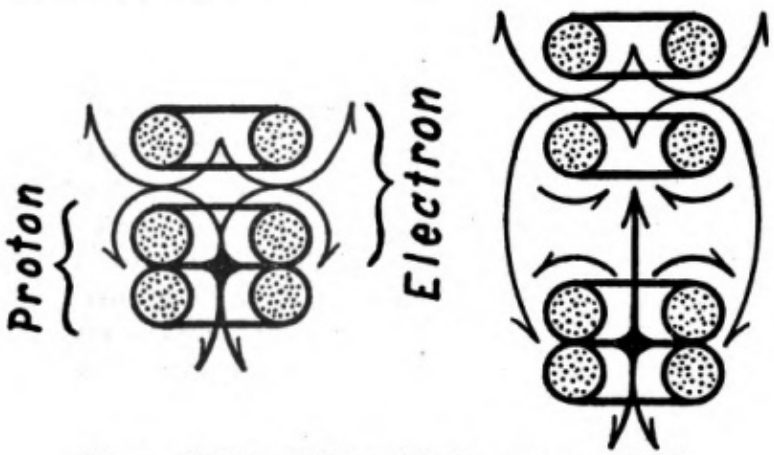

Fig. 14. Neutron (left) and hydrogen atom (right).

The hydrogen atom would then have approximately the structure shown in the diagram at the right, but we are not yet in a position to say which half of it is the proton and which half the electron.

Let us first consider this question from the theoretical standpoint. In Fig. 15 in the diagram at the left is shown a pair of vortex rings with their equatorial flux directed inwardly and their polar flux directed outwardly, while in the diagram at the right is shown the converse arrangement. The long arrows in each case represent random ether currents which encounter these vortex rings from the outside.

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If the rotating filaments of ether vortex rings are subject to the Magnus effect, as they presumably must be in a viscous

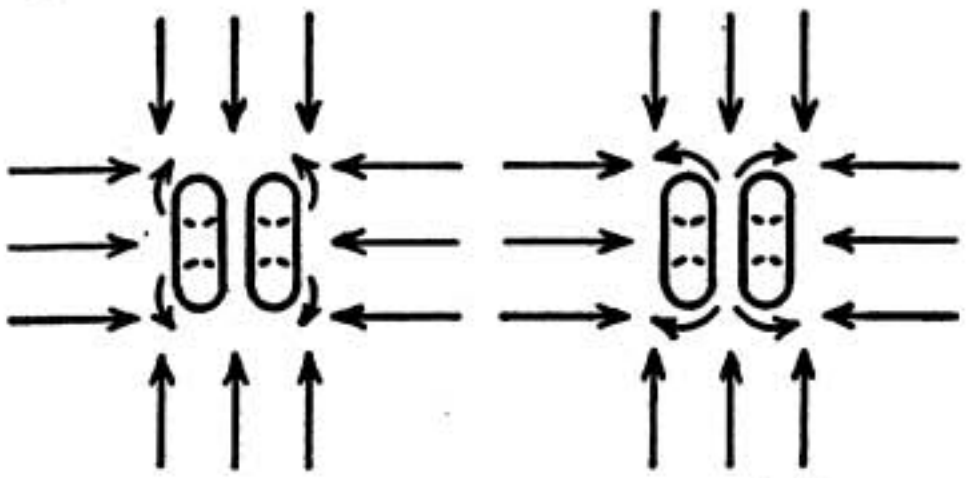

Fig. 15. The Magnus effect on protons and electrons.

or quasifrictional ether, then the effect of the horizontal arrows in the diagram at the left will be to make the rings increase in diameter, while the vertical arrows will make the two rings move more closely to each other. Exactly the opposite of these two effects will be produced in the diagram at the right. In their equilibrium position the two rings at the left will therefore be more firmly joined to each other than the two rings at the right. In these diagrams the ether currents from outside sources have been represented as acting directly on the vortex filaments, but similar results will be produced if the elementary particles of matter do not consist of vortex filaments at all, but only of centers of circulation. The effect in each case should be a dilation of the polar sources, a contraction of the polar sinks, a widening of the equatorial sources, and a pinching together of the equatorial sinks. Bearing in mind that the proton has more mass than the electron, and is therefore more difficult to destroy, it seems that the structure at the left must be the proton and the structure at the right the electron.

The foregoing description of the Magnus effect is however only a qualitative statement of what happens. It is not likely that all these effects occur in equal amount, and we still do not know which of them predominates. It is important to bear in mind that protons are about 1,800 times more

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massive than electrons, and the mass of a proton must have its origin in the gyrostatic effect of the circulating or rotating ether, either inside or outside the vortex rings. The greater mass of the proton as compared with the electron may then be attributed either to a greater speed of circulatory movement of the ether, or to a greater volume of circulating ether, or to the difference in geometric structures.

If the proton is larger than the electron, and its greater size is the result of the Magnus effect, then the vortex filament itself must be thicker in the proton than in the electron. This assumption leads to difficulties, however, when we try to draw a picture of the neutron, because the middle vortex ring is part of the electron as well as part of the proton. It therefore seems more likely that the greater mass of the proton is due to its unique geometric structure, rather than to a difference in size. It also appears that the speed of circulatory movement in the proton must be the same as in the electron, because otherwise the three vortex rings of the

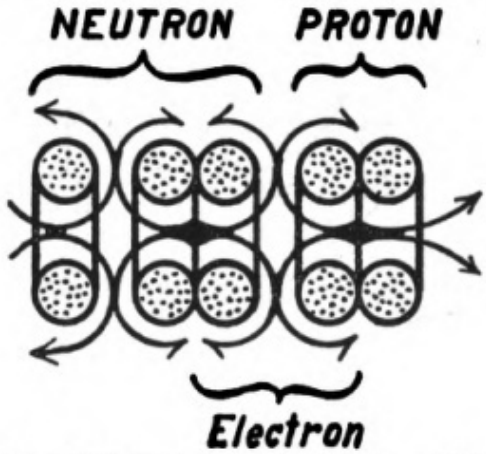

Fig. 16. Double weight neutron, formed by the collision of an ordinary neutron and a proton.

neutron could not be in rolling contact with each other.

The neutron shown in Fig. 14 has the same mass as the proton, but when such a neutron collides with a proton travelling in exactly the right direction and at the proper speed, so as to bring the adjacent surfaces into rolling con-

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tact, there will be formed a double weight neutron as shown in Fig. 16. The electron which is formed *de novo* at the instant of collision serves to hold the neutron and the proton together by a force of attraction which has been called "supergravitation". This force of attraction was predicted by the writer in 1931 in the following words:

> If both charges are of the same sign, then . . . as the two charges are brought more closely together . . . the force of repulsion will gradually disappear and leave the two charges firmly united. (*Can Science Explain Life?*, p. 92.)

The same prediction was repeated by the writer in 1933. (*The Mechanistic Autonomy of Nature*, p. 23.) Three years later, in 1936, this force was discovered experimentally.

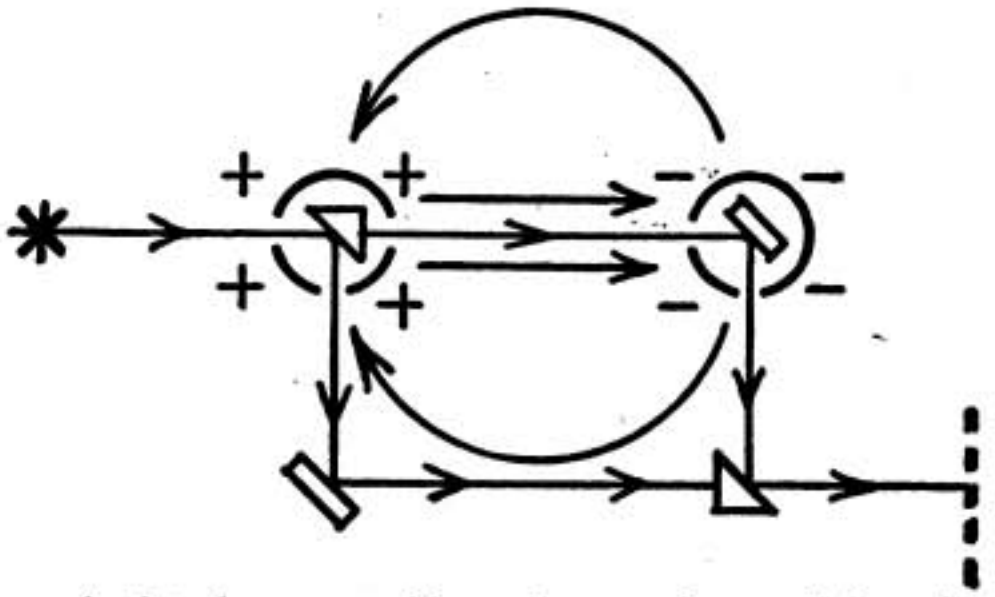

Fig. 17. An interferometer with an electrostatic potential gradient along one of the bifurcated beams.

If one proton and one electron produces the system of ether currents shown in the diagram of the hydrogen atom in Fig. 14, then many protons and many electrons should produce a similar system of ether currents, but on a larger scale. In order to test for the presence of such ether currents, the arrangement of apparatus shown in Fig. 17 may be used. An interferometer of approximately square form has hollow metal spheres or cylinders placed over two of the corners. These spheres or cylinders are then charged electrostatically as shown so that there will be an electro-

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static potential gradient along one of the bifurcated beams. If there is a flow of ether along electrostatic lines of force as indicated by the short straight arrows, then there should be a shift of the interference fringes when the electrostatic field is applied, provided the ether flows with sufficient velocity to produce an observable effect. Furthermore the direction of the shift would tell us which of the two arrangements shown in Fig. 15 is the proton and which is the electron. The same information would also be obtained from the magnetic experiment illustrated in Fig. 12, if the latter should be found to give positive results.

Another experiment that should be tried is to arrange two wires in parallelism as shown in Fig. 18, and then pass a beam of plane polarized light along a path parallel to the wires and about midway between them, but slightly above or below the level of the wires. If the electrostatic field consists of a direct flow of ether from the positive to the negative charge, (or *vice versa,*) and a return flow through outside paths, then there should be a rotation of the plane of polarization when the wires are given opposite electrostatic charges.

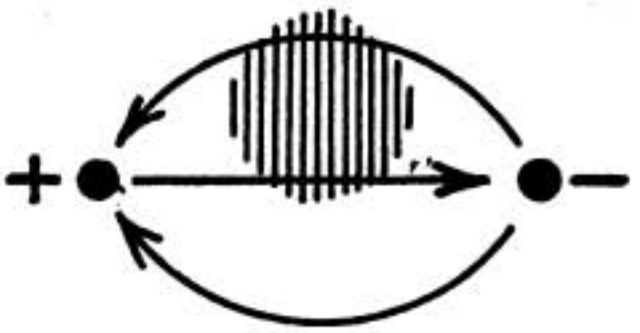

Fig. 18. Transverse section through a pair of parallel wires charged electrostatically, with a beam of plane polarized light parallel to the wires and slightly above the plane in which they lie.

The diagram of the hydrogen atom in Fig. 14 clearly shows why the electron cannot fall into the proton, the reason being that upon close approach the surfaces of these two particles will rub each other in opposite directions as indicated by the short curved arrows. Under the nuclear theory the only explanation that can be offered is that the centrifugal force of the orbital electron will keep it away

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from the proton, but even then it would radiate away its energy and eventually fall into the center of attraction. On the other hand if we make the *ad hoc* assumption that an orbital electron does not radiate away its energy, then we are really not dealing with an electron at all, but with something else. This is typical of the sort of "explanations" offered under the nuclear theory wherein the behaviors of the atoms are attributed to certain arrangements of electrons, and then those electrons are made to behave in a manner in which point charges of electricity never do behave. It may be true that the nuclear theory has been successfully fitted to some of the facts of physics and chemistry, but it would be difficult to invent any theory of atomic structure which could not be fitted to any facts. The nuclear theory has not been anywhere near as successful as it should have been if it were true in its major features. Our present textbooks do not make a fair appraisal of the situation. They place exaggerated emphasis on the few and rather dubious "successes" of the nuclear theory, but generally say nothing about its difficulties and contradictions.

It is generally stated that like electric charges repel each other, whereas unlike charges attract. This, however, is not the whole truth. If we charge one body electrostatically to minus 1,000 volts, and another body to minus 2,000 volts, they will repel each other because they have like charges. But if we take these two charged bodies into some region of the upper atmosphere where there is an absolute potential of —1500 volts, they will attract each other. Electrostatic attraction and repulsion is therefore not merely a function of the charges, but also depends on the coöperation of the environment, namely on the way in which the circulating ether of the protons and electrons encounters that from extraneous sources.

It will not be necessary to explain electrostatic attraction and repulsion separately, because the one depends on the other. The movement of unlike charges toward each other necessarily involves the movement of each of these away from other like charges in the environment. In the hydrogen

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atom, for example, the proton and the electron will keep the surrounding ether in circulation, so that it will encounter and rub against the ether currents from external sources and be repelled thereby. The proton and the electron of the hydrogen atom will therefore be repelled from all sides, *except* from the sides adjacent each other. When a proton is in close proximity to an electron, the outward polar or

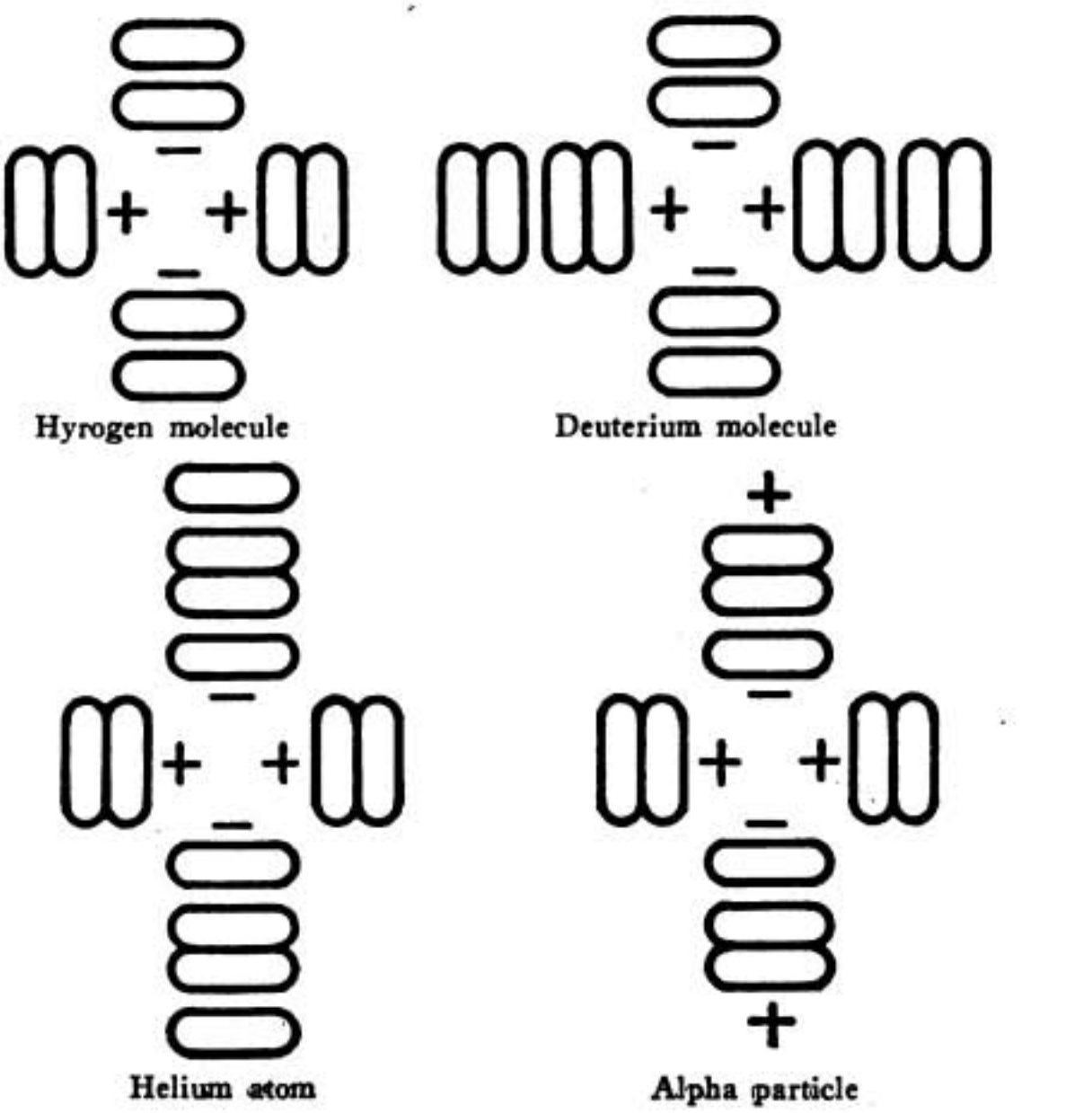

Fig. 19. Hydrogen molecule (upper left), and deuterium molecule (upper right). Helium atom (lower left), and alpha particle (lower right).

axial flux from the proton will form a continuous line of flow with the corresponding inward flux of the electron, and will find an external return path through the radial or peripheral flux. These circulating streams of ether which inter-

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link the proton with the electron will assume the form of a larger vortex as indicated by the long curved arrows, and will be endowed with the same stability which is characteristic of vortex motion generally. Attraction between unlike charges necessarily results from the formation of such larger vortex because it is only on its external sides where it will rub against and be repulsed by ether currents from extraneous sources. Internally it will encounter only its own axial flux, which will always be in the same direction and will therefore not cause any rubbing and consequent repulsion.

In any theory of atomic structure, physical and chemical properties must be determined by the peripheral architecture of the atom or molecule. In the nuclear theory, as well as in the vortex theory, the hydrogen molecule is similar to the deuterium molecule in that both are four-sided structures with two removable electrons which accounts for their similarity in properties. The nuclear theory, however, does not explain why helium is inert. The nucleated helium atom is also supposed to have two removable electrons, and should therefore be chemically active, just like the hydrogen molecule. This difficulty does not exist in the vortex theory wherein the helium atom consists of two ordinary protons and two negative protons as shown in Fig. 19. When it is subjected to rough treatment, as during an electric discharge, one or both of these negative protons may lose their terminal vortex rings so as to eliminate their outermost electrons, resulting in the formation of singly or doubly charged helium ions (e. g. alpha particles). The erstwhile negative protons are thus converted into neutrons. Each of these neutrons consists of three vortex rings, the inner two of which constitute an electron, whose connections with the two neighboring protons have not been disturbed by such ionization. In the hydrogen or deuterium molecule, on the other hand, the integrity of the entire structure will be destroyed if the peripheral electrons are removed.

The proponents of the nuclear theory tell us that the peripheral properties of atoms and molecules are determined

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by the number of outer electrons, but they do not explain why helium with only two outer electrons is so similar to neon with eight in its outer shell, while beryllium which also has an outer shell of two, or carbon with its outer shell of four, or oxygen with its outer shell of six, are so different from neon. If it is a matter of symmetry, as nuclear physicists say it is, then the beryllium, carbon, and oxygen atoms should be quite inert. Under the vortex theory the neon atom consists of one central and four peripheral helium groups so that its peripheral properties should be substantially the same as those of helium.

Another inconsistency of the nuclear theory is that the emission of radiation by inert gas atoms is attributed to their ability to become separated from their peripheral electrons, whereas their chemical inertness is attributed to their inability to separate from their electrons. Under the vortex theory the emission of radiation does not require the bodily removal of electrons, but may be accomplished by the removal of single vortex rings so as to expose peripheral

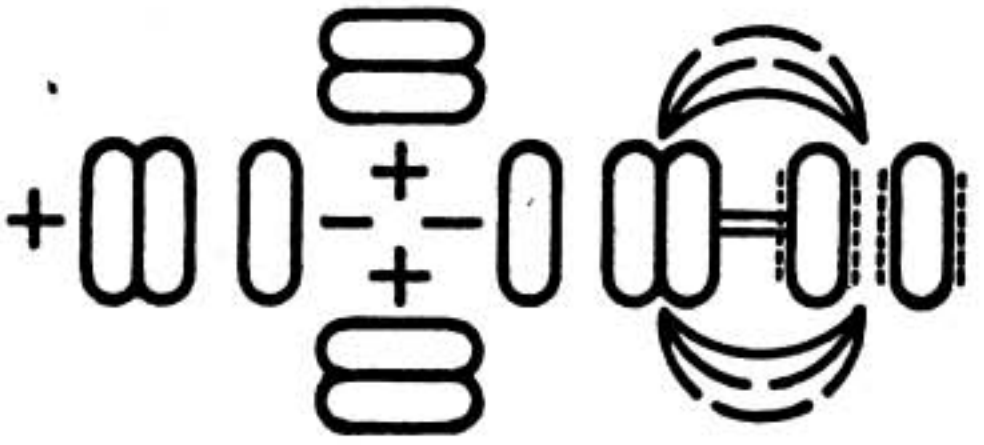

Fig. 20. A peripheral helium group with a captured electron. Helium groups occur in the peripheral structures of nearly all atoms, and when such a helium group becomes ionized and captures an electron it forms an atomic oscillator similar to the hydrogen atom. There is still much uncertainty as to the exact mode of vibration of atomic oscillators, and the showing in the above diagram is intended only as a symbolic representation.

positive charges on the helium groups as shown in Fig. 20. Any stray electron that is captured by such a peripheral helium group should then be capable of absorbing and emitting radiation.

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Hydrogen gas consists of two allotropic forms, orthohydrogen and parahydrogen, which ordinarily occur in the ratio of 3 to 1, and which differ only slightly in their properties. At very low temperatures and under pressure, and especially in the presence of charcoal, there is a rapid conversion of orthohydrogen into parahydrogen. At higher temperatures the parahydrogen gradually reverts into orthohydrogen until the equilibrium ratio of 3 to 1 is reached.

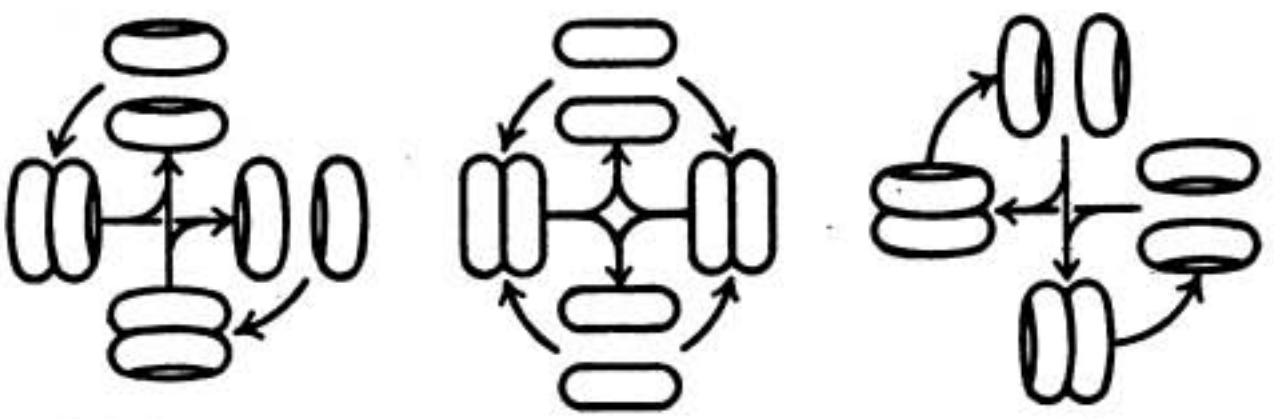

Fig. 21. Orthohydrogen (left and right) and parahydrogen (center).

Can these two forms of molecular hydrogen be accounted for structurally, or is it necessary to invoke mysterious "spins" which do not obey the ordinary laws of mechanics and electrodynamics? Under the nuclear theory it is manifestly impossible to account for them structurally because the nucleated atom has no structure—at least none that can be represented diagrammatically as a plausible picture of physical reality. In the new vortex theory we do have the required structure—a complex system of circulating ether currents which should be capable of assuming different configurations of stable equilibrium.

The hydrogen molecule in the vortex theory consists of two atoms which may be interlinked either by means of their polar flux as in the diagram at the left, or by means of their peripheral flux as in the diagram at the right, or by both as in the diagram in the center. The fact that two different structures are theoretically available for orthohydrogen need not worry us because one of these may be

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unstable. It is better to have too many possibilities than too few as under the nuclear theory.

As is clearly shown in the diagrams, the parahydrogen molecule is flat and symmetrical and will retain its symmetry while traversing a tapering magnetic field as in the Stern and Gerlach experiment. The inert gas atoms behave in a similar manner, as might be expected from the stability and symmetry of their atomic structures. On the other hand the orthohydrogen molecule will always be more or less tetrahedral and unsymmetrical so as to exist in two enantiomorphic forms, which will be deflected in opposite directions in a tapering magnetic field. While traversing such a field the protons will be acted upon by a transverse force in one direction and the electrons by a transverse force in the opposite direction. Both the orthohydrogen and the parahydrogen molecules will therefore be drawn into the tetrahedral form, but only the orthohydrogen molecules will be unsymmetrical. Monovalent atoms like sodium behave in a manner similar to orthohydrogen, as might be expected from the resemblance of their valence bonds to hydrogen molecules.

Since hydrogen groups are present in all other atoms except those of the inert gases, it would be reasonable to expect such hydrogen groups to exhibit similar configurations in the atoms of other elements, and this is what seems to be indicated experimentally. For example, the sodium atom is deflected by a tapering magnetic field in the same manner as hydrogen, but helium and neon are not deflected. Apparently the inert gas atoms exist only in the para-configuration. This is not surprising because inert gas atoms consist entirely of helium groups, and we know that the helium atom is stronger and less flexible than the hydrogen molecule.

The two negative protons of the helium atom carry exposed electrons at their outer ends, and there are reasons for believing that these maintain a strong flow of ether laterally outward in all directions so as to behave like large disks. In the hydrogen molecule this outward flow of ether from the electrons is taken up by the adjacent protons, whereas in the helium atom there are no protons immediate-

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ly adjacent the *outer* electrons. The helium atom will therefore be shaped somewhat like two parallel disks, and these will not permit sufficient tilting for the atom to remain permanently in the tetrahedral form.

The fact that atoms of different elements produce series of spectral lines very similar to one another seems to indicate that the atomic oscillators of the different elements are likewise of similar constitution. For example, the Pickering series of the helium spectrum is so similar to the Balmer series of the hydrogen spectrum that it was at one time mistaken for the latter. Since the hydrogen atom consists of only one electron and one proton, it must be assumed that the successive lines of the Balmer series represent successive positions of the electron relative to the proton. The helium atom has no *removable* electrons, but we may assume that the two outermost vortex rings of the negative protons can be readily knocked off. This is a reasonable assumption because the energy equivalent of an electron is only 500,000 volts, as against 930 million volts of the proton. The electron is therefore much more easily destroyed than the proton, so that if any part of the helium atom is ruptured, it will be one of the electrons.

Removal of an outermost vortex ring from one of the negative protons will leave the helium atom with an exposed positive charge, so that it should behave similarly to the hydrogen *ion*. If it picks up a stray electron as shown in Fig. 20 (which may be produced *de novo* from the knocked off vortex rings), then we may expect this electric doublet to behave in a manner similar to the hydrogen atom and produce a similar series of spectral lines. Besides the Pickering series, helium also produces several other series of lines, which may be accounted for by assuming that the *other* negative proton can also undergo a series of similar transformations. It may simply lose its terminal vortex ring so as to be left with an exposed positive charge, or it may then pick up another stray electron which can also assume a series of different positions.

The assumption which has just been made concerning the

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formation of electrons *de novo* is corroborated by the continual formation of negative electricity in the earth. The entire surface of the earth is at all times negatively charged to such an extent that the atmosphere in the neighborhood of the earth is kept under a constant potential gradient of 150 volts per meter. (*SCIENTIFIC MONTHLY,* July 1935, p. 50.) This causes a continual outward flow of about 1,000 amperes into interstellar space, which would completely discharge the earth in a short time if the electricity were not replenished. This must result from an actual synthesis of electrons from non-electric material, and the vortex theory furnishes the only available explanation.

We shall now consider the spectrum of the neutral sodium atom as produced by its valence electron, all the helium groups remaining intact. Metallic sodium, when sufficiently heated, produces a monatomic vapor whose absorption spectrum is a converging series of lines, known as the "principal series", each of which represents a transition from one of the abnormal or excited states of the "P" sequence to the normal state, the latter being the lowest state of the "S" sequence. Upon closer examination each line of the principal series will be found to be a doublet, which is known as the "fine structure". Each line of each doublet can be further resolved into a smaller doublet, known as the "hyperfine structure". According to the nuclear theory, the principal series is produced by transitions of the valence electron from those orbits which have an angular momentum of $2(h/2\pi)$ to the smallest orbit of zero angular momentum. The latter is supposed to be either a "straight-line orbit", a "spherical cloud of electrification", or a "probability region"—whatever these may mean. In order to account for the fine structure, the nuclear theory assumes that the *electrons* can spin on their axes in one direction or the other, but in order to account for the hyperfine structure a similar spin is attributed to the nucleus. Does it not seem strange that two structures as different from each other as the electron and the nucleus should have the same spinning movement, and with similar effects on the spectral lines?

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There are no such inherent difficulties in accounting for the fine and hyperfine structures under the vortex theory. In the vortex atom the peripheral hydrogen and helium groups are joined to the central helium group by elastic swivel connections which will permit these peripheral groups to arrange themselves in any one of several different positions of stable equilibrium, somewhat like the gear-shift lever of an automobile. Since the frequencies of oscillation of the atomic oscillators will depend on the electric fields in which such oscillators are positioned, and since these electric fields are determined by the locations or orientations of the adjacent hydrogen and helium groups, it appears that all the necessary conditions are present in the vortex atom for the production of the fine and hyperfine structures.

The alleged success of the nuclear theory has been predicated principally on the calculation of spectral frequencies by the use of the Balmer and Rydberg formulas, but these can be derived independently of the concept of orbits. The only assumption which needs to be made in the derivation of these formulas is that energy is absorbed or radiated in integral multiples of a unit quantum, and the theory of quantization of energy is just as compatible with the vortex theory as with the nuclear theory. There is also nothing in any of the wave atom calculations of the new quantum mechanics that requires the existence of an atomic nucleus as distinguished from the structural center or center of inertia of the vortex atom.

We have thus far been considering only those particles which are permanent structural units of the atoms. There are also other particles like the positron and the mesotron which appear to have only transitory existence and differ from other known particles only in mass. It is believed that these can be readily accounted for on the theory that the electric charge of a particle is determined by the number and arrangement of its constituent vortex rings, whereas its mass is determined by the external ether currents interlinked therewith. Since there cannot be a fractional number of vortex rings, and since there is only a limited number of

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ways in which such rings can be arranged with respect to one another, it necessarily follows that the electric charges of the elementary particles must be in the relation of small whole numbers to one another. On the other hand it is conceivable that the interlinked ether currents may have any arbitrary magnitude so that the masses of the elementary particles may vary accordingly. Why some particles like the positron and the mesotron are unstable cannot be explained in the present state of our knowledge, but neither can it be explained under the nuclear theory.

The mesotron under the vortex theory would have the general form of one of the negative protons of the helium atom, but the two inner vortex rings (which would normally constitute the proton) would have less than the usual volume of circulating ether associated therewith. This interpretation of the mesotron has been corroborated by a recent photograph which showed a mesotron track terminating in a gas, and a fast electron track emerging from its end. (*NATURE*, Jan. 20, 1940, pp. 102-103.) The kinetic energy of the electron track was found to be much greater than the kinetic energy of the mesotron, but was comparable with its mass energy, which is exactly what would be expected if one of the electrons of the mesotron became captured by a positive ion and the other electron then broke away with the elimination of the partially formed proton at the center.

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TABLE II

Masses of Elementary Particles

Electron	Neutron	Proton	Deuteron	Triton
.0005	1.0090	1.0081	2.0147	3.0171

Hybridium
3.0171

Helium	Lithium	Beryllium	Boron	Carbon	Nitrogen	Oxygen	Fluorine
4.0039	6.0167	9.0149	10.0161	12.0036	14.0073	16.0000	19.0049
	7.0180		11.0128	13.0073	15.0048	17.0046	
						18.0038	

Neon	Sodium	Magnesium	Aluminum	Silicon	Phosphorus	Sulphur	Chlorine
19.9986	22.997	23.9938	26.9911	27.9860	30.9844	31.9812	34.9796
21.9985				28.9864		33.9799	36.9777
				29.9845			

Argon
35.976
37.9753
39.9754

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Vortex Atom Structures

SINCE the hydrogen molecule consists of two protons and two electrons, and the alpha particle of two protons and two neutrons, it appears that electrons and neutrons are interchangeable in such structures. Let us therefore substitute a neutron for one of the electrons in the hydrogen molecule. Since the resulting structure will have a net charge of plus one, it should be possible to substitute it for one of the protons of a helium atom as shown in the

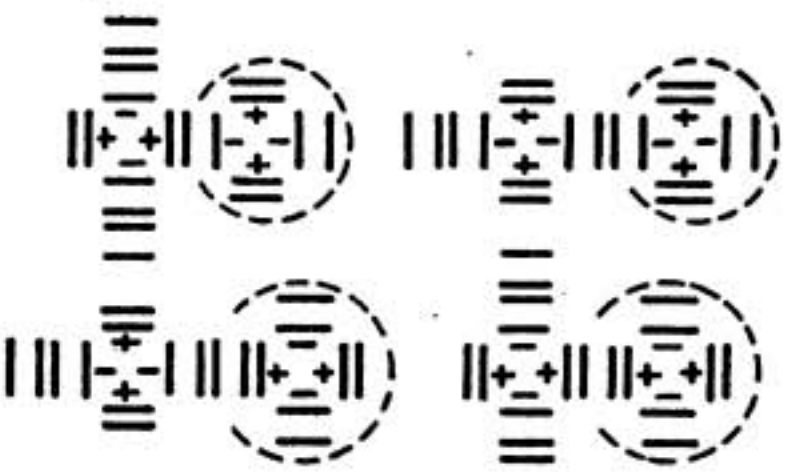

Fig. 22. Four theoretically possible forms of the lithium atom of atomic weight 6. Each heavy line represents one vortex ring, viewed edgewise. The preferred form is shown in the upper left diagram.

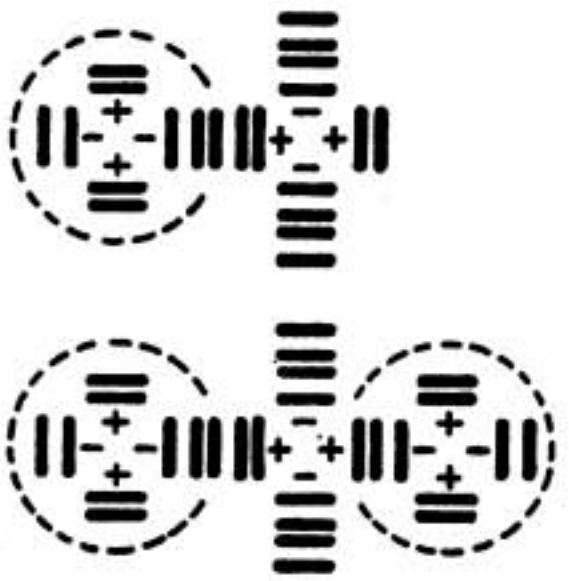

Fig. 23. Lithium atom (above) and beryllium atom (below), of atomic numbers 3 and 4 and atomic weights 7 and 9 respectively.

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upper left diagram of Fig. 22, and thus produce a new kind of atom which can only be the lithium atom. By making a similar substitution on the other side of the same helium atom, it should be possible to produce the beryllium atom.

As shown in Fig. 22, there are three other ways in which it appears theoretically possible to attach a hydrogen molecule to a helium atom, but the resulting structures would not account for the physical and chemical properties of lithium and beryllium. It is not likely, for example, that the lithium and beryllium atoms have protons at the free ends of the hydrogen groups, because such protons would readily dissociate therefrom and leave the remaining structures strongly electronegative. It is also not likely that the lithium atom would have a negative proton at the free end of the helium group, because if another hydrogen group were added to form the beryllium atom, the latter would not have any exposed negative protons to furnish the neutrons that are actually produced in great abundance when beryllium is bombarded. Furthermore the melting points of these elements could not be satisfactorily accounted for on the basis of such alternative structures.

In the preferred form of the lithium atom the portion within the dotted circle is not an ordinary hydrogen mole-

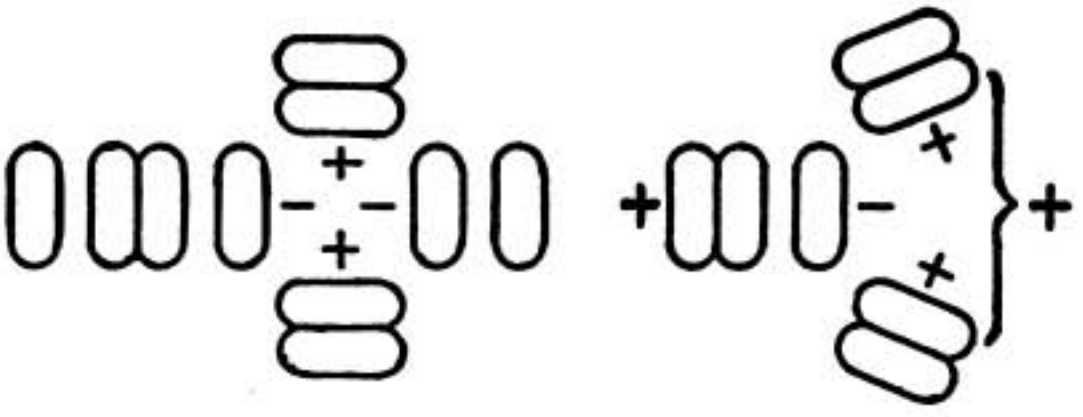

Fig. 24. Hybridium atom and ion of atomic number 1.5 and atomic weight 3.

cule, but has a neutron in place of one of the electrons so as to constitute a hybrid of hydrogen and helium. Such a structure is probably identical with what has been described in recent publications as the helium isotope of atomic weight 3,

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but according to the vortex theory there cannot be any lower isotope of helium. The vortex theory does however require the existence of a particle that is constituted as shown in Fig. 24, and which has been named "hybridium" with the symbol Hy by V. M. Waage.

In its completely ionized condition shown in the diagram at the right, this particle will have a positive charge of two, and might readily be mistaken for a lower isotope of helium. (*PHYSICAL REVIEW*, *56*, 379 & 613, 1939.) Such a particle should constitute a true atom and not a molecule because the negative proton (or the neutron when in the ionized condition) will keep it from going to pieces as in the case of the hydrogen molecule. It should have a chemical valence of one, and should be strongly electropositive because the two protons at the sides are not guarded by helium groups as effectively as in the atoms of the electronegative elements. It should behave like the first member of the alkali metal group, and should occupy the place usually allotted to hydrogen which is really not a metal at all. It is also significant that the helium spectrum has not yet been obtained from this alleged helium isotope, and the atomic weights also discredit the conclusion that it is a helium isotope.

Normal helium has atomic weight 4.0039 while its alleged isotope has atomic weight 3.0171. The difference is 0.9868, or considerably less than 1.0, whereas the difference in atomic weight between the isotopes of all other elements in the neighborhood of helium is greater than 1.0. If it were really an isotope of helium, then its atomic weight should be about three-fourths that of ordinary helium, or about 3.0027, which is far less than its observed atomic weight of 3.0171.

On the other hand if it is the first member of the alkali metal series, then it may be considered as retaining only one-quarter of the normal helium structure, namely the one negative proton, which would have a weight of about $4.0039/4 = 1.0010$. The two remaining protons may then be considered as parts of a hydrogen group and will have a combined

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weight of 2(1.0081)=2.0162. Adding up, this gives a total atomic weight of 3.0172 which is almost exactly the observed atomic weight.

If this system of construction were to be continued, then the boron atom would appear as shown in Fig. 25 with two of its hydrogen groups having an electron outermost, but the third one having a proton outermost. It seems improbable, however, that the hydrogen groups which constitute the valence bonds should be of two different types, and for reasons previously given it also seems improbable that any of these hydrogen groups carry protons at their outer extremeties.

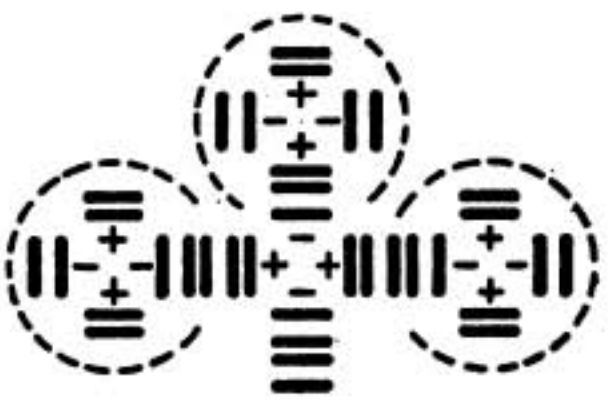

Fig. 25. A hypothetical structure approximating that of the boron atom, but not believed to be entirely true to fact.

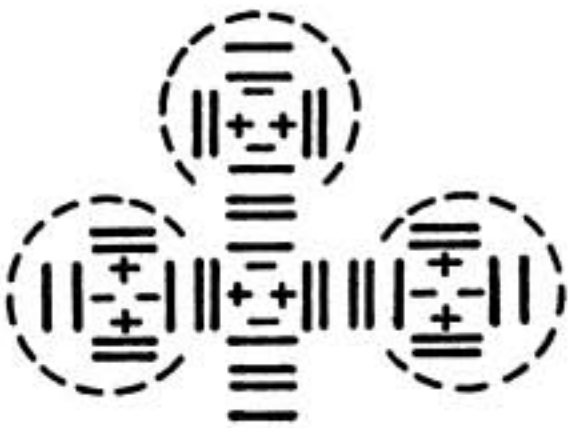

Fig. 26. Boron atom of atomic number 5 and atomic weight 11.

It seems more likely that the boron atom is constituted as shown in Fig. 26. The only difficulty with this latter structure is that the neutral atom contains eleven protons but only ten electrons, whereas it is generally thought that in a neutral atom there must be as many electrons as protons.

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However, the recently discovered force of attraction between protons at close range (sometimes called "supergravitation") proves that electrically charged particles do not exert their usual electrostatic forces at intra-atomic distances but behave in an anomalous manner. It appears, therefore, that we are not justified in making the generalized assumption that in every neutral atom the electrons and the protons must occur in equal numbers.

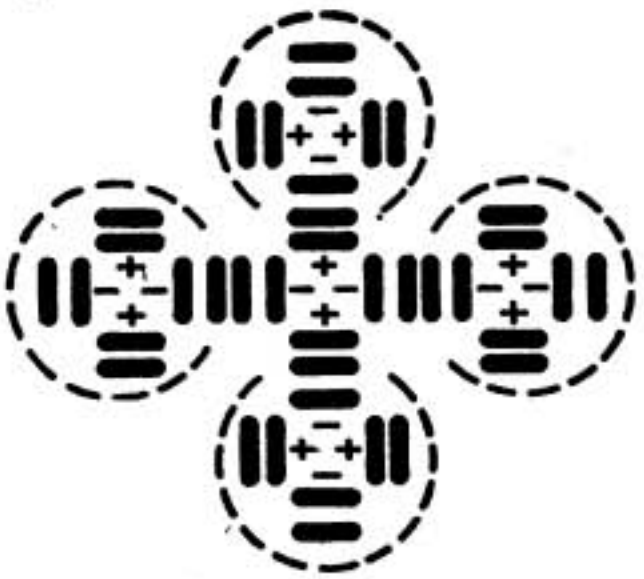

Fig. 27. Carbon atom of atomic number 6 and atomic weight 12.

In the diagrams of the lithium, beryllium, boron, and carbon atoms in Figs. 23, 26, and 27, only the predominant isotope is shown in each case. In order to produce the lithium isotope of weight 6, an ordinary neutron would have to be substituted for the double weight neutron as in the upper left hand corner of Fig. 22. Since the external structure of the atom is not appreciably changed by such a substitution, the physical and chemical properties would remain the same.

In the series of elements from lithium to carbon, the central helium group becomes progressively covered by hydrogen groups. Since helium is an inert gas, the presence of helium groups in the periphery of an atom should tend to keep it in a fluid (liquid or gaseous) condition, whereas the hydrogen groups, which constitute valence bonds, should tend to keep the atoms anchored to one another as in a solid. Consequently as the central helium groups become progress-

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ively covered by hydrogen groups, the melting points should become higher. Thus lithium with its helium group exposed on three sides melts at 186°, beryllium with its helium group exposed on two sides melts at 1280°, boron with its helium group exposed on one side melts at 2300°, and carbon with its helium group exposed on no side remains solid up to about 4000°. Of the 92 chemical elments, carbon is the only one

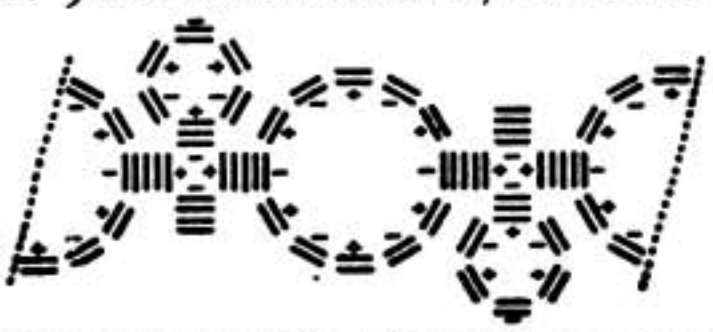

Fig. 28. Diborane molecule C_2H_6. Since this is a ring-shaped structure, it was necessary to split it open and spread it out flat to show it clearly.

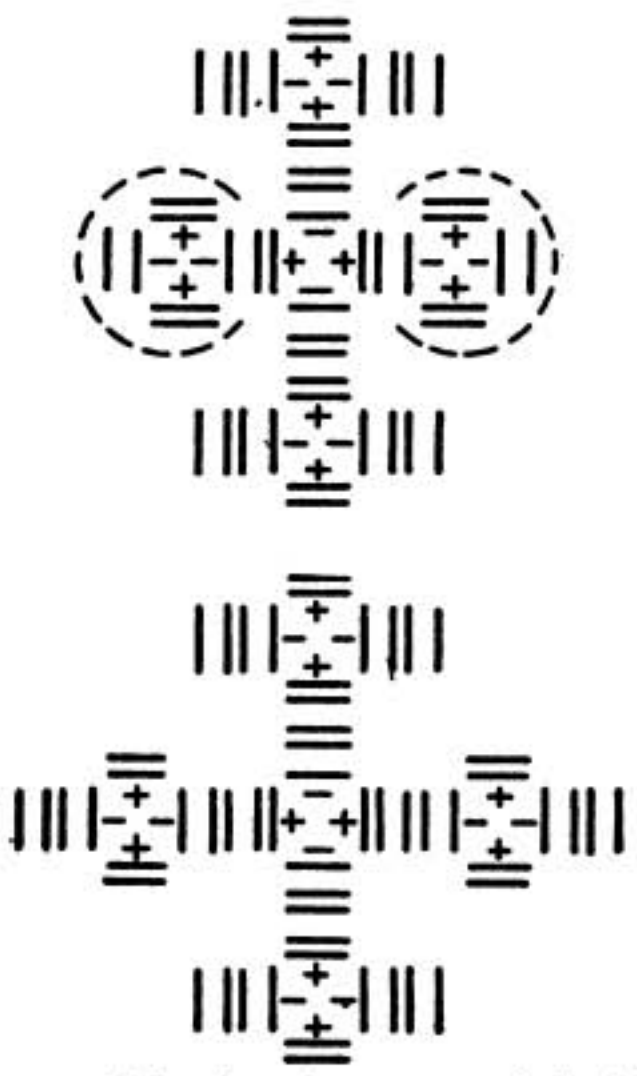

Fig. 29. Oxygen atom (above) and neon atom (below) of atomic numbers 8 and 10 and atomic weights 16 and 20 respectively. The nitrogen and fluorine atoms may be supplied by obvious interpolation.

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(besides hydrogen) which has no *exposed* helium groups. This is probably the reason why carbon is the most refractory of all elements.

Before leaving this series of elements attention should be directed to diborane B_2H_6, a gaseous substance whose molecules consist of two boron atoms and six hydrogen atoms. (*NATURE*, Feb. 27, 1937, pp. 381-382.) Now the boron atom under the nuclear theory has only three valence electrons, whereas the diborane molecule would require boron atoms with at least four electrons each. As the diagram shows, biborane can be accounted for without difficulty under the vortex theory. (*NATURE*, Jan. 8, 1944, p. 59.)

There is still some doubt as to the positions of some of the peripheral helium groups in the elements from nitrogen to neon. It is possible that they may all be positioned so as to have their negative protons outermost.

After passing carbon in the series of elements we cannot add any more hydrogen groups to the periphery of the atom, but can only change the hydrogen groups, one by one, to helium groups. This will produce the atoms of nitrogen, oxygen, fluorine, and neon. It will be noted that the number of elements in the first horizontal row of the periodic table is exactly what the vortex theory requires. If there were one more or one less, then the entire vortex atom theory would have to be discarded. That the atomic structures of these elements are actually formed in the manner above described is also corroborated by their melting points. Since there is a progressively increasing number of peripheral helium groups as we pass from nitrogen to neon, the melting point should go down at each step, and so it does. Nitrogen melts at —210°, oxygen at —218°, fluorine at —223°, and neon at —249°. This cannot be merely a series of chance coincidences. There are nine different elements from helium to neon, and a series of nine melting points can be arranged in factorial 9 or 362,880 different ways. Only one of these corresponds to the actual arrangement of the melting points of the known chemical elements, and that is the very one that this vortex theory requires. And furthermore this

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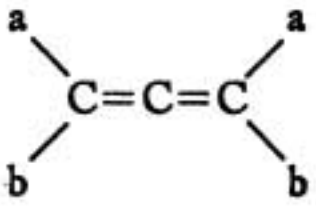
agreement of melting points with vortex atom structures is not limited to the first horizontal row, but holds true throughout the greater part of the periodic table, except where the structures become so complicated that other factors enter into the problem.

The atomic structures shown in the diagrams have been spread out flat in the plane of the paper, but in reality they extend into three dimensions of space. The carbon atom, for example, should be capable of buckling from the flat configuration into either of two enantiomorphs, and it seems likely that such buckling actually occurs in the Walden inversion and during racemization by heat, and perhaps also during certain kinds of metabolism. Such buckling of the carbon atom will also explain the conversion of *l*-chloro-succinic acid into its *d*-isomeride by treatment with moist silver oxide to produce *l*-malic acid, and then the conversion of the latter into *d*-chloro-succinic acid by treatment with PCl_5. It will also explain the racemization of mandelic acid (by heating in heavy water) without keto-enol tautomerism. (*NATURE*, Sept. 26, 1936, p. 547.) It will also explain why glutaconic acid

$$COOH.CH:CH.CH_2.COOH$$

has been found to exist in only one form, and will probably also account for the difficulty of separating the optically active forms of allene derivatives of the type



There is a gradual change from electropositiveness to electronegativeness while passing from the left side to the right side of the periodic table. Now electropositiveness simply means the tendency to lose negative electrons, whereas electronegativeness means the tendency to hang on to such electrons. In any system of atomic structure it must be

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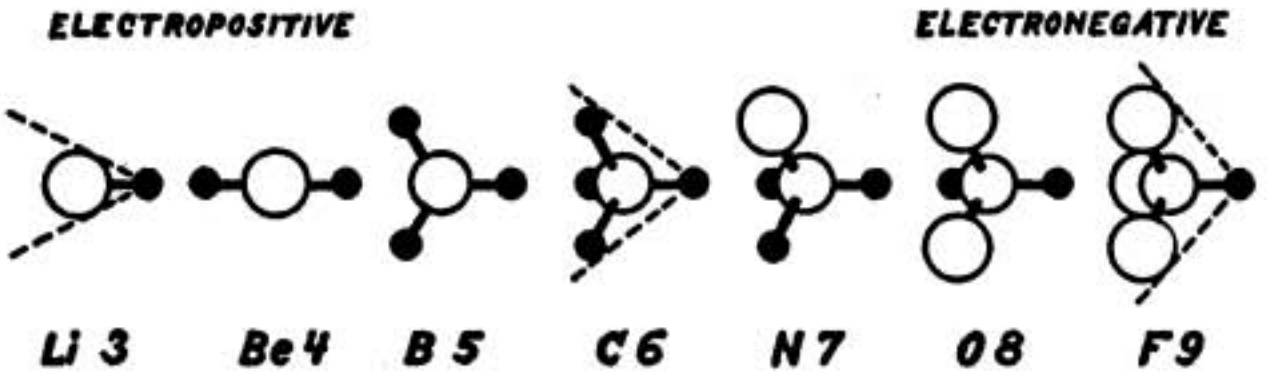

Fig. 30. Diagrammatic representation of the elements of the first horizontal row of the periodic table. Each circle represents one helium group, and each solid black dot represents one hydrogen group or valence bond. The dotted lines indicate the gradual change from electropositiveness to electronegativeness.

the protons that are responsible for the retention of the negative electrons. If these protons are well guarded against attack from the outside, then they will be able to hang on to their electrons more firmly than if they are in exposed positions. An inspection of the diagrams in Fig. 30 will show that the protons of the peripheral hydrogen groups are more exposed in the atomic structures at the left side of the periodic table than in the structures at the right side. Under the nuclear theory no such explanation is possible because there are no peripheral helium groups in the nucleated atom. On the contrary, the electrons themselves become more crowded in the periphery of the nucleated atom as we pass from the left side toward the right side of the periodic table. Under the nuclear theory the electronegative elements should therefore occur at the left side and the electropositive elements at the right side of the periodic table, and this difficulty cannot be eliminated by conjuring with the mystic word "octet".

Molecular nitrogen remains very inert, even at high temperatures, whereas molecular oxygen is one of the most reactive substances known. The nitrogen molecule must therefore be a much more stable structure than the oxygen molecule. Under the nuclear theory the only difference in surface structures between the nitrogen and oxygen atoms is that the former has five peripheral electrons whereas the

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latter has six. If symmetry of electronic configurations has anything to do with stability, then it would appear, under the nuclear theory, that the *oxygen* molecule should be the more stable and the less reactive of the two.

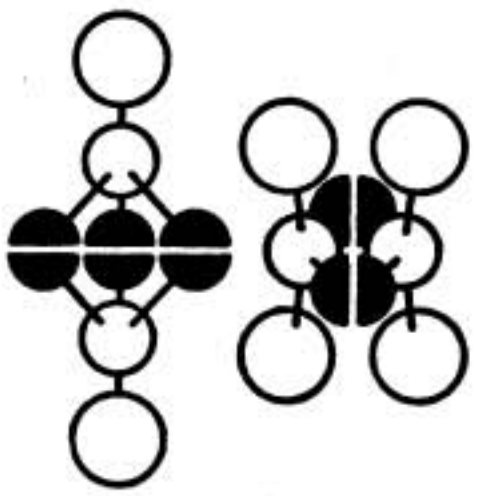

Fig. 31. Nitrogen molecule (left) and oxygen molecule (right).

Under the vortex theory the nitrogen atom is tetrahedral in form and has one peripheral helium group and three peripheral hydrogen groups which serve as valence bonds. In the diatomic nitrogen molecule the helium groups will therefore be diametrically opposite each other with the valence bonds midway between them, whereas in the diatomic oxygen molecule the helium groups of the two atoms will be closely adjacent each other so that their thermal vibration will cause repulsion between the two atoms in opposition to the binding effort of their valence bonds. This explains on a purely geometric basis why oxygen is chemically more reactive than nitrogen.

If nitrogen molecules are constituted as shown in Fig. 31, then they should be quite similar in structure and physical behavior to molecules of carbon monoxide, because the CO molecule also consists of a cluster of valence bonds with two helium groups near the center, and two peripheral helium groups on opposite sides of the molecule. Such similarity of structure is corroborated by the melting and boiling points of these substances, nitrogen and carbon monoxide melting at —210° and —207°, and boiling at —196° and —192° respectively. The few degrees difference between the melt-

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ing and boiling points of nitrogen and those of carbon monoxide is probably due to the fact that in the nitrogen molecule the valence bonds are clustered more closely around the center and the peripheral helium groups are slightly further apart than in the carbon monoxide molecule.

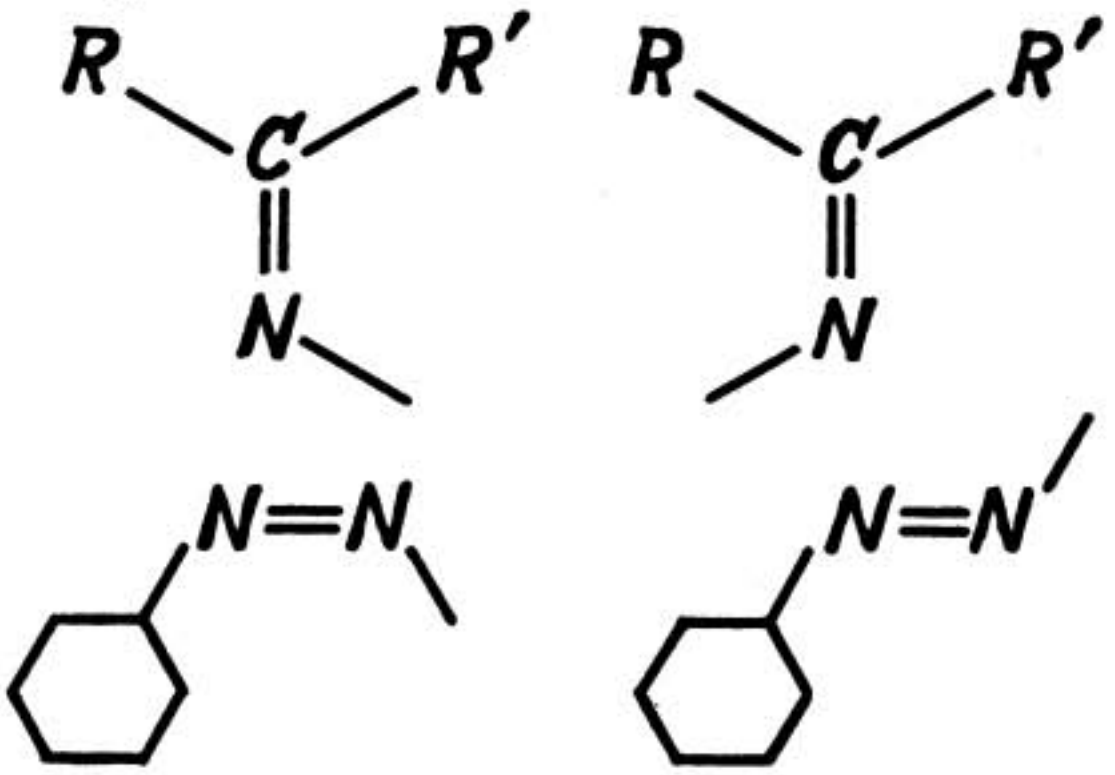

Fig. 32. Isomerism of oximes (above) and diazo compounds (below).

The tetrahedral form of the nitrogen atom is also corroborated by the isomerism of unsymmetrical oximes, diazo compounds, and hyponitrous acid, each of which occurs in two different forms with slightly different physical and chemical properties. Such isomerism is exactly what the vortex theory requires, whereas under the nuclear theory it cannot be explained. The three valence elctrons of the nuclear trivalent nitrogen atom would distribute themselves uniformly about the center of the atom. The fact that the three valence bonds crowd over to one side proves that there must be something on the other side to push them over, which can be nothing other than a peripheral helium group. Such an explanation is not possible under the nuclear theory because all helium groups of the nucleated nitrogen atom are in the nucleus, far removed from the periphery where the valence electrons are located. The presence of a fourth and

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fifth electron in the periphery of the nucleated nitrogen atom does not help any, because these would tend to arrange themselves symmetrically at the poles.

Although the existence of unsymmetrical oximes, diazo compounds, and hyponitrites in two different geometric forms seems to prove that the trivalent nitrogen atom is tetrahedral with the three valence bonds on one side of the atom, nevertheless the failure of all attempts to produce optically active substituted amines of the type N*abc* has thrown some doubt upon this conclusion. Since optically active carbon compounds of the type C*abcd* can be produced, even when one of the substituents is a hydrogen atom, it appears that whatever is present at the fourth corner of the nitrogen atom must be slightly smaller than the hydride group so as to permit buckling of the nitrogen atom in substituted amines where each of the substituents is capable of free rotation, but at the same time it must be something large enough to prevent such buckling where two of the valence bonds are in the form of a double bond so as to make free rotation impossible. The nitrogen vortex atom with its peripheral helium group has exactly the required structure, this helium group being just a little less bulky than a hydride group.

Another difficulty of the nuclear theory is that the average distance between electrons in the same shell is much greater than the distance between shells. It is therefore difficult to understand why the electrons should confine themselves to definite shells at all, instead of assuming a generally staggered arrangement. This difficulty is further aggravated by the introduction of elliptical orbits which could not possibly be confined to their respective shells.

Under the nuclear theory it would also be difficult to account for the relatively high heats of formation of double and triple bonds between carbon atoms, which are 252 and 365 gram calories respectively, as compared with 136 gram calories for single bonds. Bearing in mind that two spherical objects can touch each other at only one point, and that electrons repel each other, it appears that under the nuclear

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theory the heats of formation of double and triple bonds could not be much greater than the heat of formation of single bonds. It is different in the vortex atom where the

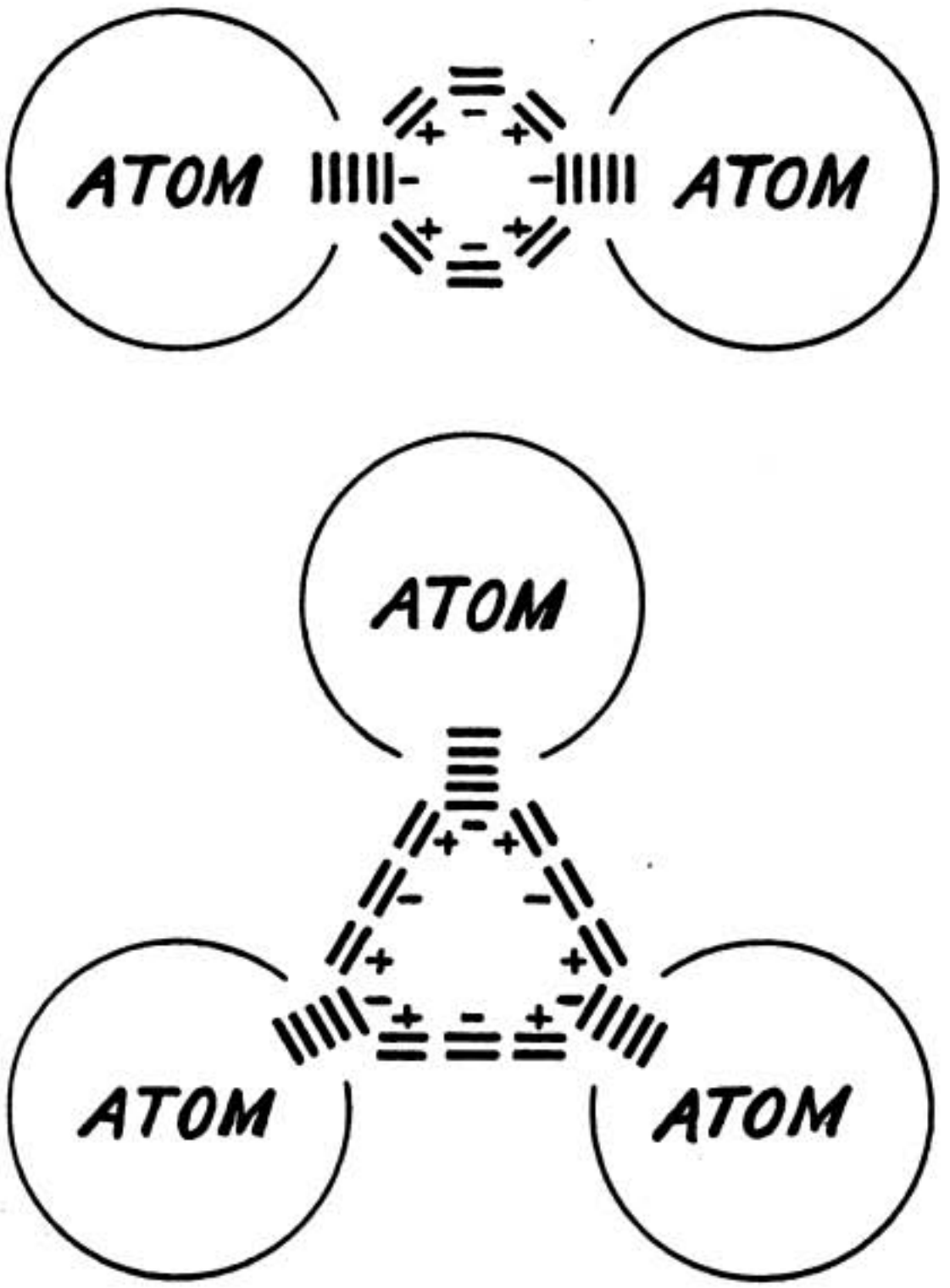

Fig. 33. Ordinary valence bond (above) and branched valence bond (below).

electrons of one valence bond do not appreciably oppose those of adjacent valence bonds.

The valence bond under the nuclear theory is supposed to

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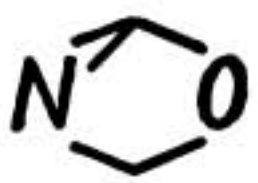
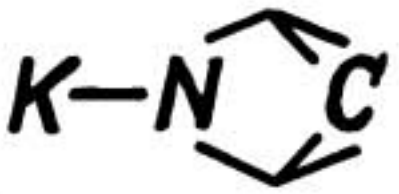
be formed of one or more electrons floating freely in the space between two atoms. Bearing in mind that the outstanding characteristic of a valence bond is the firmness with which it holds the atoms at a fixed distance from each other, one could hardly imagine a more unsuitable mechanism for the purpose. Nucleated atoms with their outer shells consisting entirely of negative electricity would only repel each other, somewhat like colloidal particles having similar electric charges.

It would also be impossible to explain the rigidity of crystals with the freely floating valence electrons of the nucleated atom. The rigidity of crystals proves *ipso facto* that the individual atoms and molecules have a similar glasslike rigidity. It is conceivable that skeletal structures formed of vortex rings with interlinking ether currents might have considerable rigidity, but how any condition of glasslike rigidity could exist in structures formed of nucleated atoms with their widely scattered electrons (not to mention wave atoms) is beyond the understanding.

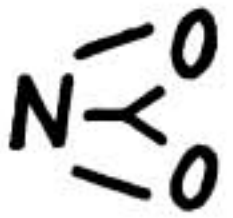
Under the nuclear theory the valence bond can form a junction between only two atoms, which is necessarily so because three or more spherical structures cannot be brought into contact with one another at a single point. Junctions between three or even four atoms are however possible under the vortex theory, as shown in Figs. 33 and 34. Such multiple junctions probably also occur abundantly in metals. Metallic crystals are made up of single electrically neutral



Nitric Oxide



Potassium Isocyanide



Nitrogen Peroxide

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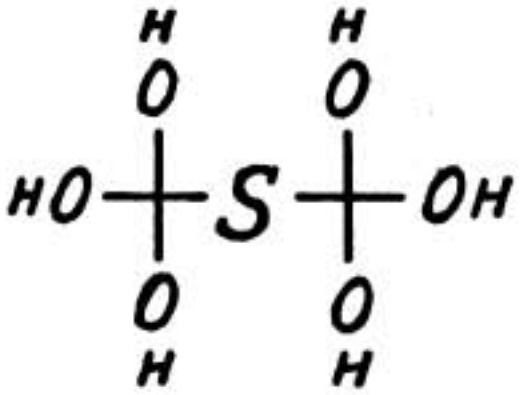
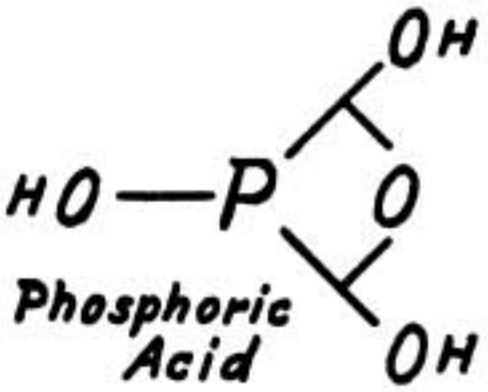
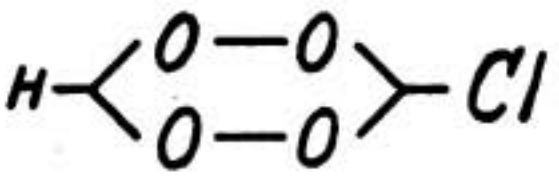
Carbon Monoxide



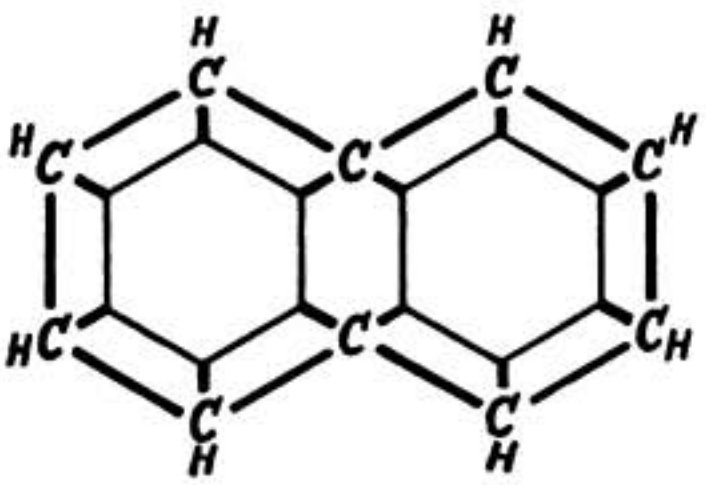
Sulphuric Acid (dilute)



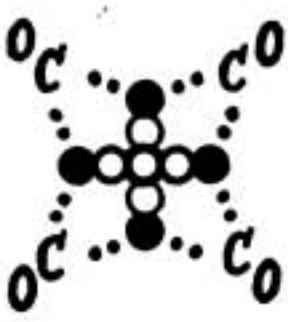
Phosphoric Acid



Perchloric Acid



Naphthalene



Nickel Carbonyl

Fig. 34. Familiar compounds with branched valence bonds.

atoms packed closely together and joined to one another by their valence bonds in such a manner that each atom is in contact with eight to twelve others. In the case of monovalent metals such a structure can be produced only by branching of the valence bonds.

The branched valence bond is also of particular interest

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with refernce to the benzene ring structure. The Kekulé structure with alternate single and double bonds will not account for the presence of only one ortho-substitution product unless we assume that the single and double bonds in the benzene ring are continually in a state of tautomeric interchange, and we know from numerous other carbon compounds that alternate single and double bonds do not generally act in this manner. The centric formula of Armstrong and Baeyer is in agreement with all known facts about benzene derivatives, but represents an impossible structure under the nuclear theory because valence electrons floating freely about the atomic nuclei of the carbon atoms would arrange themselves on the outside and not on the inside of the benzene ring.

It has also been suggested that the carbon atoms of the benzene ring may be joined to one another by valence bonds consisting of three electrons between every two adjacent carbon atoms. This three-electron type of bond would be just as satisfactory as the centric bond, but has not been adopted because under the nuclear theory it would not be possible to account for naphthalene, anthracene, and other condensed ring systems on the basis of such a structure.

As shown in Fig. 35, the vortex atom theory eliminates all these difficulties. The benzene ring under the vortex theory is essentially a centric structure, although it could also be interpreted as a three-electron structure. Naphthalene, anthracene, and other condensed ring structures can be formed in a similar manner without difficulty. The recently developed resonance theory of the benzene ring structure with single and double bonds in tautomeric interchange is therefore superfluous.

The peculiar ring structure that is shown in Fig. 35 is possible only with six atom rings, which accounts for their unique "aromatic" properties. In the corresponding eight atom ring, known as "cyclo-octatetrene", the central connections cannot be formed because the distances to be spanned are too great, so that cyclo-octatetrene can only have alternate single and double bonds like those of the Kekulé

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structure. This is corroborated by the fact that cyclo-octatetrene does not exhibit any aromatic properties but behaves like a typical olefine. The absence of aromatic properties in cyclo-octatetrene is also a strong argument against the resonance theory of the Kekulé structure because if six atom rings

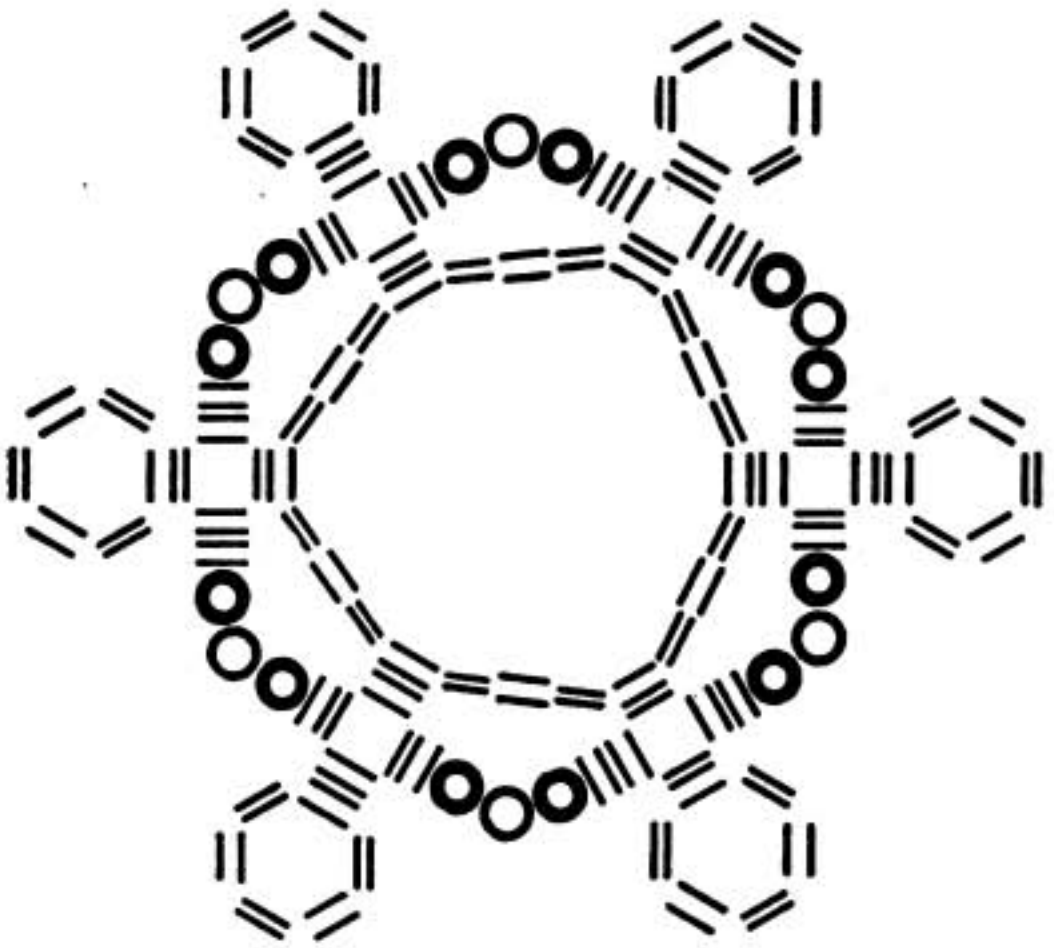

Fig. 35. The benzene ring, C_6H_6.

were capable of such a tautomeric resonance condition, then eight atom rings should also exhibit a similar condition.

The pyridine ring would have the same central structure as the benzene ring, but a helium group would take the place of one of the peripheral hydrogen groups. The presence of such a peripheral helium group on the pyridine ring will explain the miscibility of pyridine in water because water also contains similar peripheral helium groups, and it is the general rule that "like dissolves like". The solubility or miscibility of the simpler organic nitrogen and oxygen compounds in water is generally directly proportional to the

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prominence of the peripheral helium groups in the organic molecules.

It is interesting, however, that organic chlorine substitution products are generally not soluble in water. The reason for this seems to be that solubility in water depends on hydrogen bond formation, and among the simpler chemical elements hydrogen can coördinate only between atoms of nitrogen, oxygen, and fluorine, or between one of these and a carbon atom if the latter has strongly negative groups attached to it. Now the characteristic feature about the N, O, and F atoms is that each of them has one or more peripheral helium groups immediately adjacent the central helium group, which appears to be a necessary condition for hydrogen bond formation with water molecules. The effect of these helium groups in promoting hydrogen bond formation seems to be closely related to their effect of rendering the atoms at the right side of the periodic table electronegative.

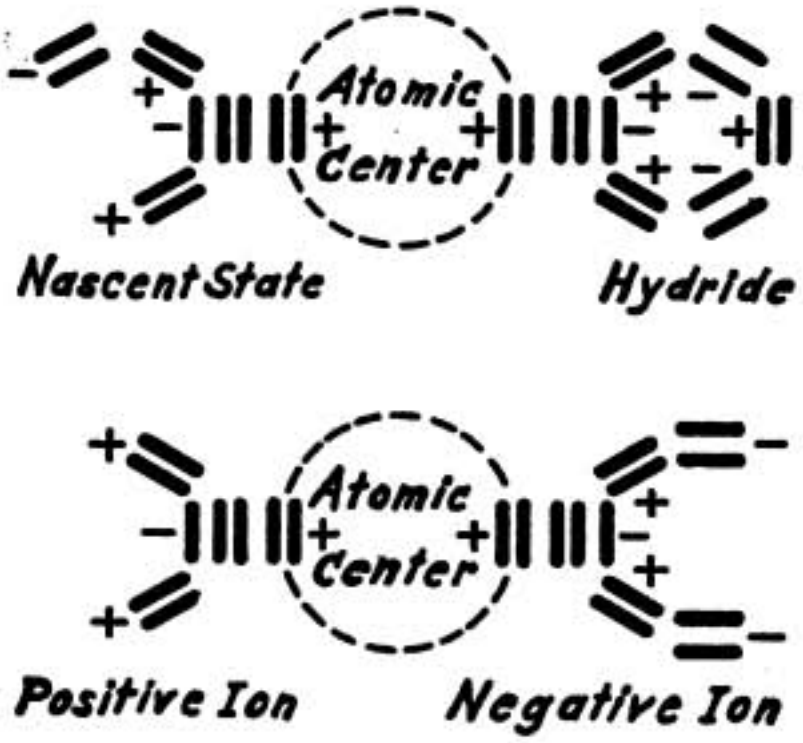

Fig. 36. Various aspects of the vortex atom valence bond.

If valence bonds are formed from hydrogen groups as taught by the vortex theory, then positive and negative ions would have the bifurcated structures shown in Fig. 36. This explains the frequent formation of negative ions from posi-

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tive ions rather than from neutral molecules. It has been found that when electrons are passed through a gas (Hg, H_2, N_2, O_2, or CO_2,) the negative ions are formed not from neutral molecules as would be expected under the nuclear theory, but from positive ions, each of which takes on *two* electrons when it strikes the cathode. (*NATURE*, July 25, 1936; p. 162; Feb. 27, 1937, p. 378; and Dec. 31, 1938, p. 1165.)

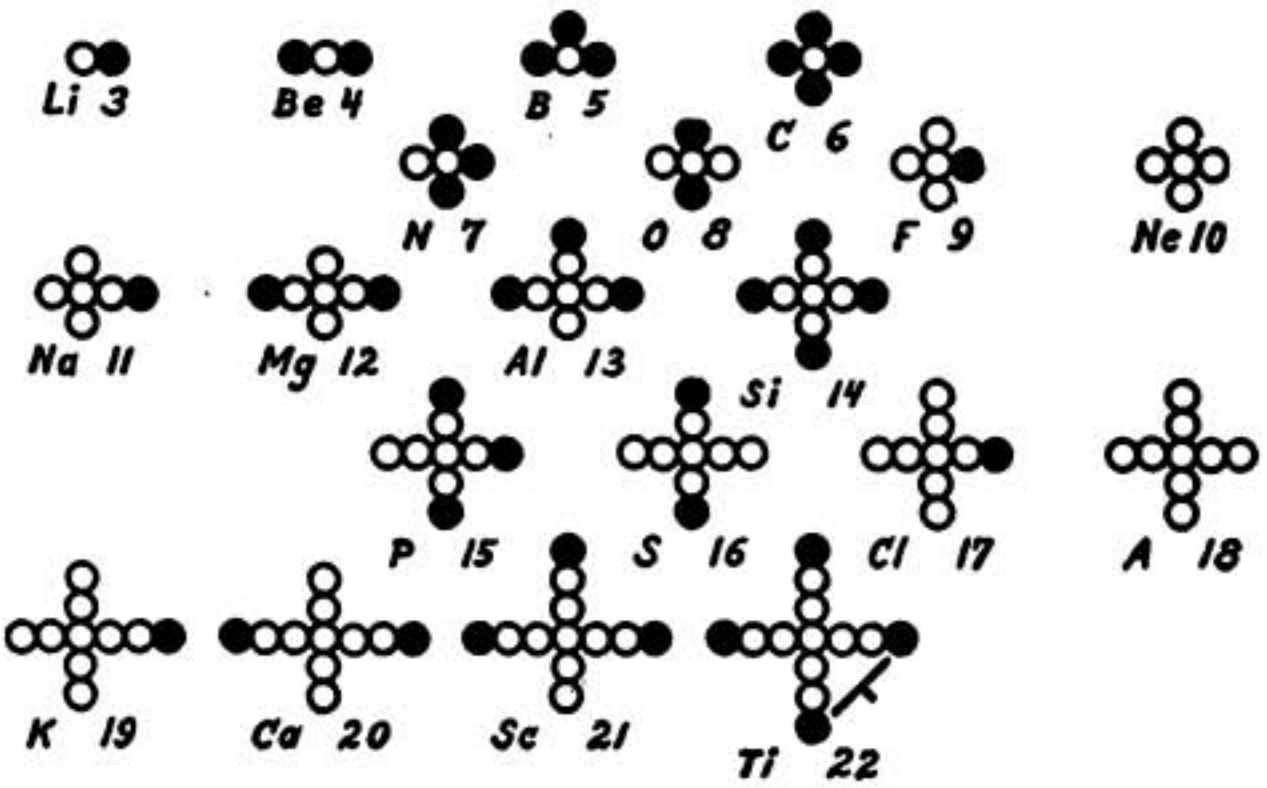

Fig. 37. Atomic structures built up on one structural center.

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TABLE III

Periodic Table of Elements

The densities and melting points are generally highest near the center of the table (in Group 4) and diminish toward either side. The numerical designations of the horizontal rows indicate the number of structural centers or branches on which the atoms are built.

H 1	0	1	2	3	4x	4	4y	5	6	7
1a	He 2	Li 3	Be 4	B 5		C 6		N 7	O 8	F 9
1b	Ne 10	Na 11	Mg 12	Al 13		Si 14		P 15	S 16	Cl 17
1c	A 18	K 19	Ca 20	Sc 21		Ti 22				
2a				V 23	Cr 24 Mn 25	Fe 26	Co 27 Ni 28			
2b		Cu 29	Zn 30	Ga 31	Ge 32			As 33	Se 34	Br 35
2c	Kr 36	Rb 37	Sr 38	Y 39	Zr 40 Cb 41	Mo 42				
3a					Ma 43	Ru 44	Rh 45 Pd 46			
3b		Ag 47	Cd 48	In 49	Sn 50			Sb 51	Te 52	I 53
3c	Xe 54	Cs 55	Ba 56	57 . 71						
4a					Hf 72 Ta 73	W 74	Re 75 Os 76 Ir 77 Pt 78			
4b		Au 79	Hg 80	Tl 81	Pb 82			Bi 83	Po 84	Ab 85
4c	Rn 86	Vi 87	Ra 88	Ac 89	Th 90 Pa 91	U 92				

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The Heavier Elements

THE second horizontal row of the periodic table follows the same general order as the first row, and this radial building up process continues into the third row with progressively increasing melting points until we pass titanium. Then there occurs a slight drop and leveling off of the melting point curve with the ushering in of new properties, such as colored compounds, irregular changes of valence, and metallic states of great hardness with the sudden appearance of ferromagnetism. After passing this series of hard metallic elements which do not fit readily under any of the preceding elements, we finally come to arsenic, selenium, bromine, and krypton, for which we again find reserved places. From there on the melting point again goes up step by step until molybdenum is reached. Just as titanium represented the end of the radial building up process from one structural center, so molybdenum represents the end of the radial building up process from two structural centers. This also explains why there were two more elements from krypton to molybdenum than there were from argon to titanium.

If the periodic table be now referred to, it will be seen that the elements in rows 1a, 1b, and 1c have atoms built up from one structural center, those in rows 2a, 2b, and 2c from two structural centers, those in rows 3a, 3b, and 3c from three structural centers, while those in rows 4a, 4b, and 4c are built up on a more complex four-branched pattern. The densities and melting points are generally highest in the center of the table (in group 4), because the number of peripheral hydrogen groups is there a maximum and diminishes toward either side.

The elements Mg, Al, Si, and P of the second row have abnormally low melting points as compared with the elements immediately above and below them, but this may be attributed to greater freedom for thermal vibration as the

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radial dimensions of the atoms increases, especially in vertical transitions from the first to the second row. The relatively higher melting points of Ca, Sc, and Ti, (which are immediately below Mg, Al, and Si,) may then be attributed to the increased distance between the valence bonds, the effect of which now predominates over the opposite effect of increased thermal vibration. The rise of the melting point in the vertical transition from phosphorus to arsenic, (the valence bonds being the same distance apart in both cases,) may then be attributed to the substitution of the argon group of the arsenic atom for the outermost helium group of the phosphorus atom. Since argon melts at a higher temperature than helium, it would be reasonable to expect arsenic to melt at a higher temperature than phosphorus.

The melting points of the halogens increase with increasing atomic weight, whereas the melting points of the alkali metals decrease with increasing atomic weights. This seems peculiar, since both the halogen and alkali metal atoms consist of one valence electron and an inert gas atom residue. In the alkali metal atom, however, the valence electron is only loosely associated with the inert gas atom residue, whereas in the halogen atom the two are firmly held together so as to form a single structure. Halogen atoms also tend to unite in pairs to form discrete molecules with the valence electrons near the centers of the molecules, so that the outer exposed portions of such molecules will consist entirely of inert gas atom residues. It would therefore be reasonable to expect the halogen *molecules* to behave in the same general way as inert gas atoms, and that may be the reason why the melting points become higher in both cases as the atomic or molecular weights increase. On the other hand in the alkali metals there are no discrete diatomic molecules, the valence electrons and inert gas atom residues being held together by general electrostatic attraction, so that their effects are purely additive. Since the valence electrons are the same for all alkali metals, the melting points of such metals must depend entirely on the inert gas atom residues, and it is reasonable to assume that when such residues are large and

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heavy they will be more effective in keeping the substance in a fluid condition than when they are small and light.

There is some uncertainty as to where the transition from one structural center to two structural centers occurs. There is some spectroscopic evidence that it occurs in the transition

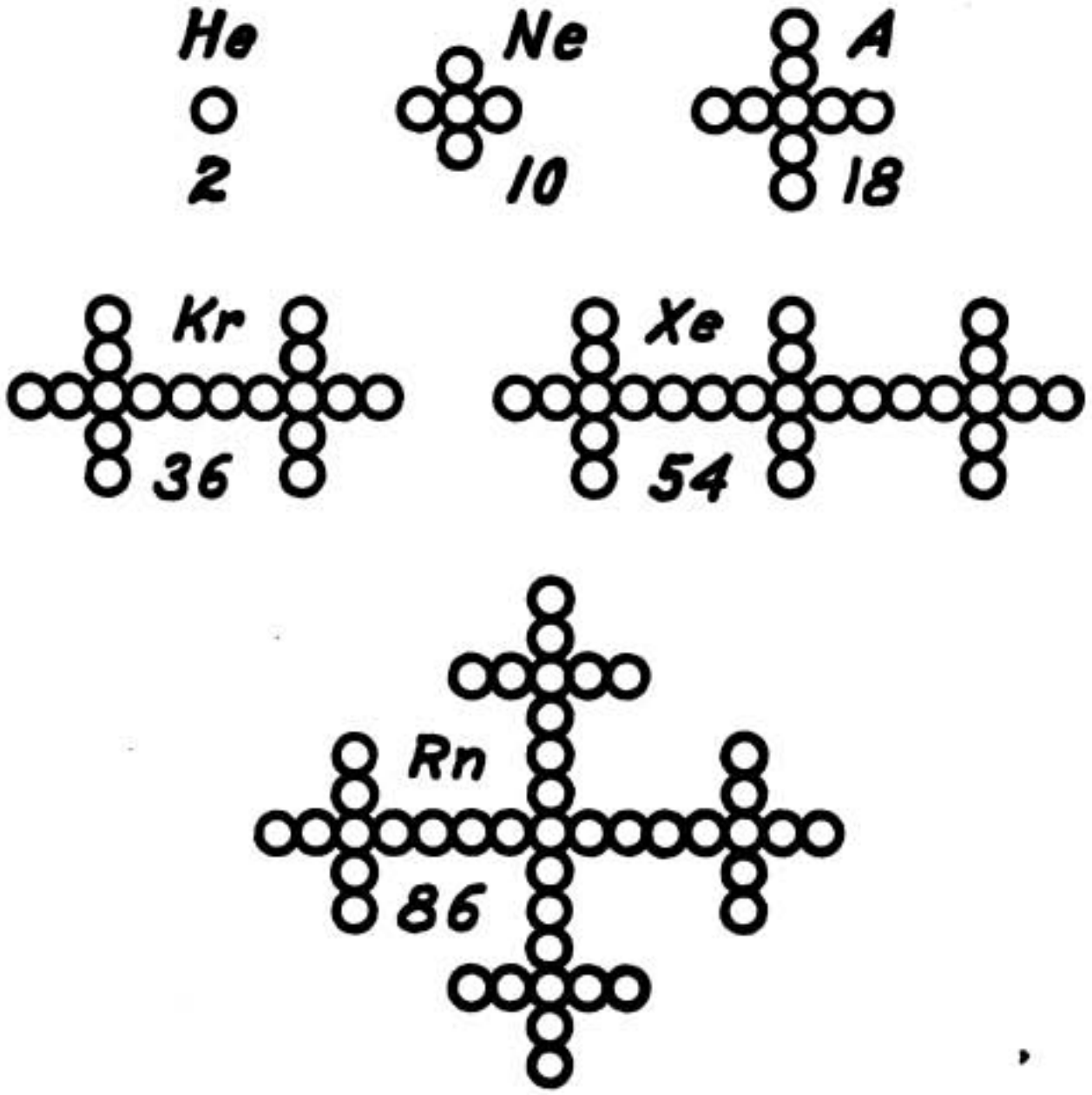

Fig. 38. Inert gas atoms.

from calcium to scandium, but scandium and titanium do not form colored compounds and their melting points and valences seem to bring them exactly in line with potassium and calcium. It is true that titanium can be trivalent, but it is usually tetravalent and in its trivalent condition two of the hydrogen groups are probably linked to each other in the form of a branched valence bond.

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If the vanadium atom has only a single structural center, then it can differ from titanium only in the substitution of a helium group for one of the hydrogen groups. This may account for vanadium when considered by itself, but vanadium clearly belongs to the series of polyvalent elements with colored ions immediately following it, and the entire series cannot be satisfactorily accounted for on the assumption that they are all built up on a single structural center. The further along we go in the periodic table the more difficulties we get into if we try to continue building upon one structural center.

The inert gas atoms are especially difficult to account for on the basis of one structural center, but as Fig. 38 shows, they can be satisfactorily accounted for if we assume that the heavier elements have multiple centers. The intermediate stages in the transitions from one inert gas structure to another are represented in the periodic table by the horizontal rows of elements. These comprise two short periods (helium to neon and neon to argon), followed by two longer periods (argon to krypton and krypton to xenon), and then by a still longer period (xenon to radon).

Although there is no direct method of ascertaining the atomic structures of the heavier elements, nevertheless we can generally arrive at some conclusion as to the plausibility of any proposed structure by determining whether it has been built in accordance with the same principles that were found to be applicable in the formation of the atoms of the lighter elements. These principles are as follows:

(1) A given number of helium and hydrogen groups will always assume an arrangement of maximum symmetry;

(2) In the same atom all terminal helium groups are in the same shell (i. e. at the same distance from the structural center to which they are attached;

(3) In the same atom all hydrogen groups are in the same shell; and

(4) Terminal helium groups are never found outside of the argon shell.

From rules (2) and (3) it necessarily follows that helium

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groups never occur in any shell in which there are vacant places not yet occupied by hydrogen groups.

The four rules stated above have been deduced from a study of the simpler atoms with one structural center, but are believed to be of general aplicability. In atoms with two or more structural centers, the following additional rules appear to hold true:

(5) Every structural center is outside of the argon shell of every other structural center; and

(6) The argon shell around the center of the atom will be tangent to either the neon or the argon shell of every remaining structural center.

From rules (5) and (6) it necessarily follows that adjacent structural centers always have at least two and never more than four helium groups between them.

The reason for all this is probably some condition of resonance in the atom, which would probably also account for the greater abundance of isotopes in the even elements than in the odd elements, the former having the greater degree of symmetry and therefore the greater stability.

If we assume that every helium group contributes two units to the atomic number and every hydrogen group one unit, then the vanadium atom must have either nine helium groups and five hydrogen groups, or ten helium groups and three hydrogen groups. Since ten helium groups would be furnished by two neon atoms, and since three hydrogen groups would account for the chemical similarity of vanad- to phosphorus, it is believed to be most probable that the vanadium atom consists of two neon groups joined directly to each other, with three hydrogen groups on their periphery. The similarity of vanadium to phosphorus in its chemical properties would seem to indicate that all three hydrogen groups of the vanadium atom are on the same neon center, but such a structure would not account for the high melting point of vanadium, or for the appearance of color in vanadium compounds. It is therefore believed that two of the hydrogen groups are on one neon center, and the third hydrogen group on the other neon center. This also

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accounts more readily for the multiple valences of vanadium. The vanadium atom may then be regarded as a close union of a sodium atom with a magnesium atom. These two atoms do not combine with each other chemically, but it is possible that under certain conditions the ionized gaseous atoms may combine with each other through their helium groups.

The chromium, manganese, and iron atoms could then be formed by the addition of hydrogen groups to the periphery of the vanadium atom. Some of these will probably form internal chemical bonds, which may or may not be branched. The multiple valences of these elements can be readily accounted for in this manner, but there would not be any *simple* relationship between the valences of these elements and the numbers of hydrogen groups on their atoms, and their melting points will also not bear any such simple relationship to the numbers of hydrogen groups as was found to exist in the first horizontal row.

The cobalt, nickel, copper, and zinc atoms could be similarly accounted for by the successive substitution of helium groups for hydrogen groups in the iron atom, which would also account for the progressive lowering of the melting point along this series of elements.

There will however be a limit to the number of helium groups that can be thus added because as the periphery becomes more crowded, the tension between the two structural centers will increase. This is probably the reason why the next element after zinc is not a monovalent element, but rather trivalent gallium with *three* helium groups between the two structural centers.

If now we make the assumption that all hydrogen groups in the same atom must be at the same distance from their respective centers, then the germanium atom could not be formed by merely adding another hydrogen group to the periphery of the gallium atom, but would have to be a new type of structure with *four* helium groups between its two structural centers. Two of the hydrogen groups of the germanium atom may under certain conditions combine with each other so as to leave the germanium atom divalent. The

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arsenic, selenium, and bromine atoms then follow in regular order.

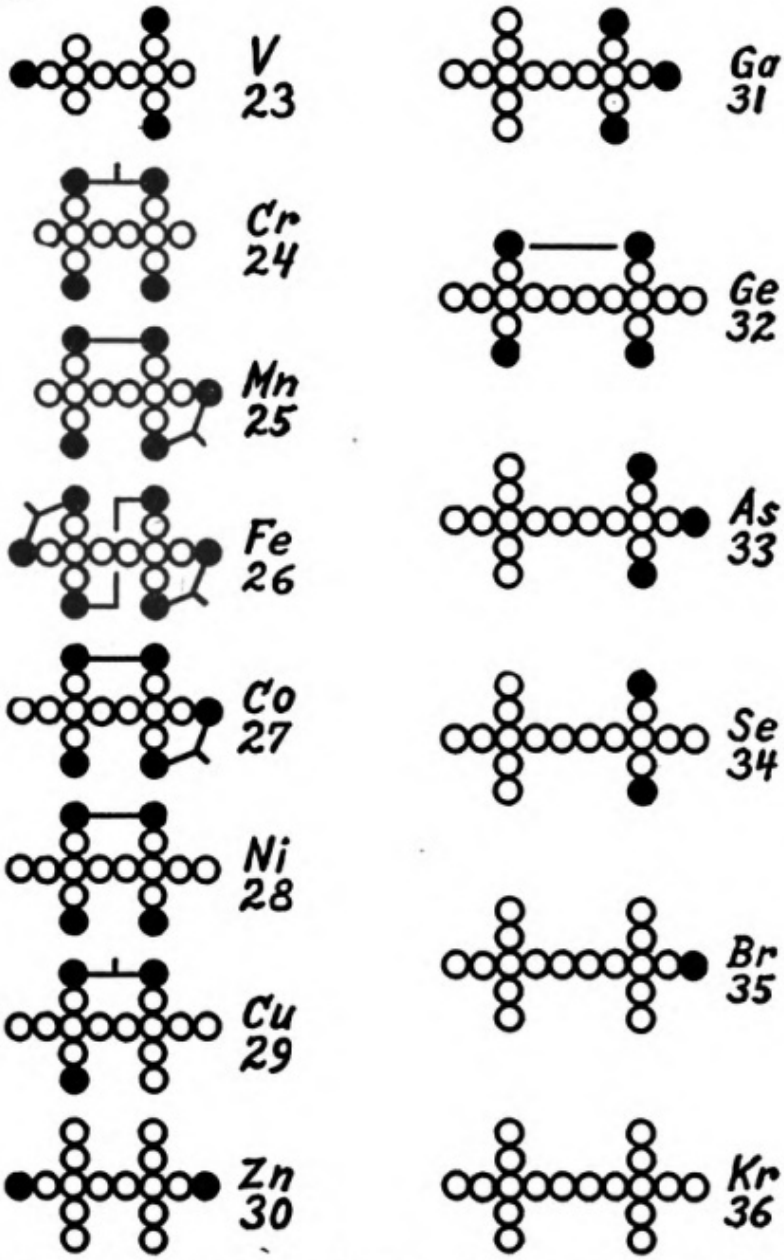

Fig. 39. Atomic structures with two structural centers. The short straight lines represent internal chemical bonds.

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In the nucleated selenium atom the two valence electrons will be most likely to arrange themselves symmetrically at opposite sides of the atom, whereas the vortex selenium atom has its two valence bonds at the corners of a tetrahedron like the sulphur atom, but differs from the latter in having an argon group attached to one of the remaining corners. It will readily be seen that if the two selenium atoms of the selenanthren molecule in Fig. 40 are arranged

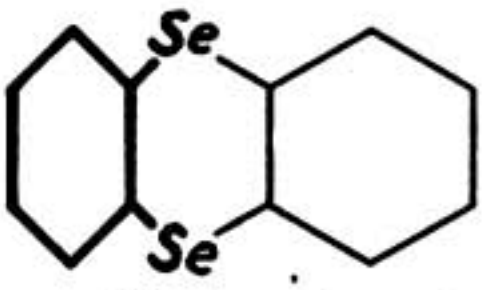

Fig. 40. The selenanthren molecule.

with their argon groups below the plane of the paper, the two benzene rings will be permanently tilted toward each other, and electron diffraction photographs have shown that the selenanthren molecule is actually folded as shown. (*NATURE*, Sept. 12, 1942, pp. 321-322.)

This structure of the selenium atom is also in perfect agreement with the physiological behavior of selenium. It is now known that what had previously been described as "alkali disease" is really selenium poisoning, the selenium atoms evidently taking the places of the sulphur atoms in the protein chemical structures. This is quite evident from the pathological spreading out of the horny structures which are normally rich in sulphur, the selenium atoms being more bulky than the sulphur atoms. The ability of selenium to take the place of sulphur in the protein chemical structure can be readily explained under the vortex theory because the two valence bonds of the selenium atom are at exactly the same angle to each other and exactly the same distance apart as in the sulphur atom, whereas in the nucleated selenium atom the two valence electrons must be presumed to be further away from each other than in the sulphur atom.

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The experimental information about masurium is very scanty, but it appears from theoretical considerations that the masurium atom cannot consist of a further development of the molybdenum atom. It must have a different internal structure, which can be nothing other than a group of three structural centers. The exact arrangement of the helium and

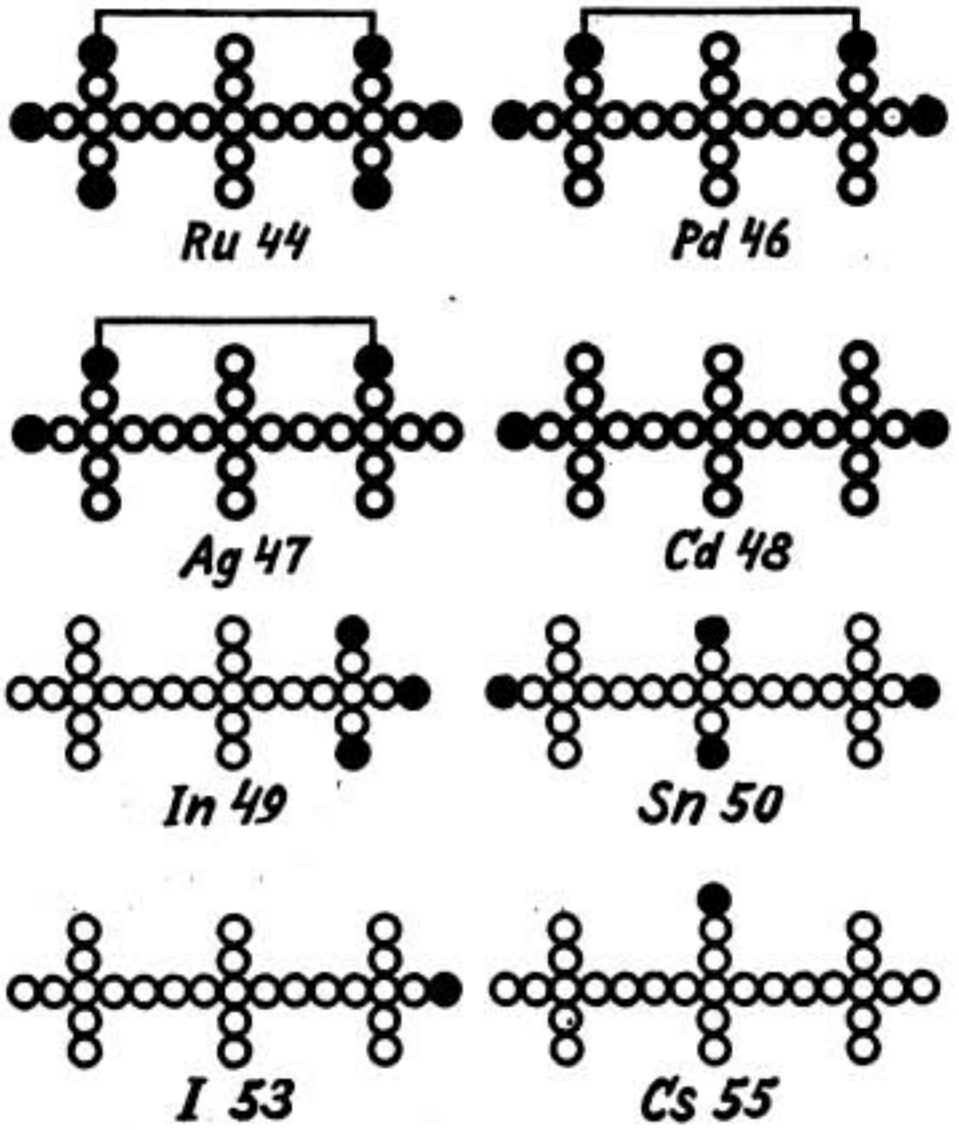

Fig. 41. Atomic structures with three structural centers.

hydrogen groups in the masurium atom is, however, still in doubt.

The ruthenium atom has its end portions completely covered with hydrogen groups, which are changed successively to helium groups until we come to cadmium. The progressive lowering of the melting point along this series of elements is evidence of such successive change of hydrogen into helium groups. If we assume that some of the hydrogen

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groups form internal chemical bonds in the same atoms, then the valences of these elements can also be accounted for.

Although silver has a valence of only one, its high melting point seems irreconcilable with the assumption that it has only one hydrogen group like the alkali metals. It seems more likely that it has three hydrogen groups, two of which are united by an internal bond. In the chloride, bromide, iodide, and cyanide of silver the internal bond is probably

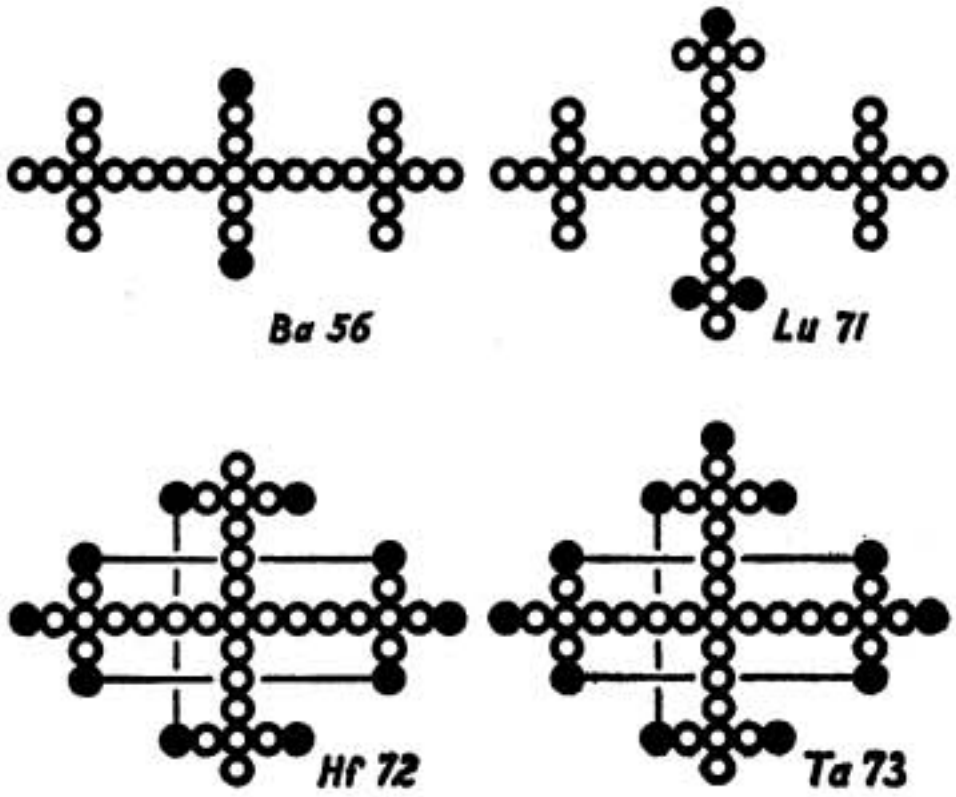

Fig. 42. Atomic structures of barium, lutecium, hafnium, and tantalum. There is still some doubt whether hafnium and tantalum are the last of the rare earths, or the first members of the tungsten-radon series.

broken by congestion within the molecule, whereupon the liberated hydrogen groups would combine with those of adjacent silver atoms to form insoluble chainlike polymers. The fluorine atom has fewer helium groups than the atoms of the other halogens, which may be the reason why silver fluoride is soluble.

The fact that nearly all the rare earths have a valence of three must be due to the structures of the entire atoms, rather than to the number of hydrogen groups in each case. Every rare earth atom consists of a xenon structure with three or more hydrogen groups, and probably also some

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additional helium groups. If the hydrogen groups were attached to the ends of the xenon structure, then it would be impossible to explain the invariable valence of three throughout the rare earth series, or the close similarity of the successive elements in their chemical properties. If the hydrogen groups are not attached to the ends of the xenon structure, then they must be attached to the central argon group. This would leave the ends of the xenon structure inert, with three free arms on each end. These may be presumed to position themselves in such a manner as to divide the space around the rare earth atom into three symmetrical zones of electrification so as to furnish only three regions through which other atoms can enter for

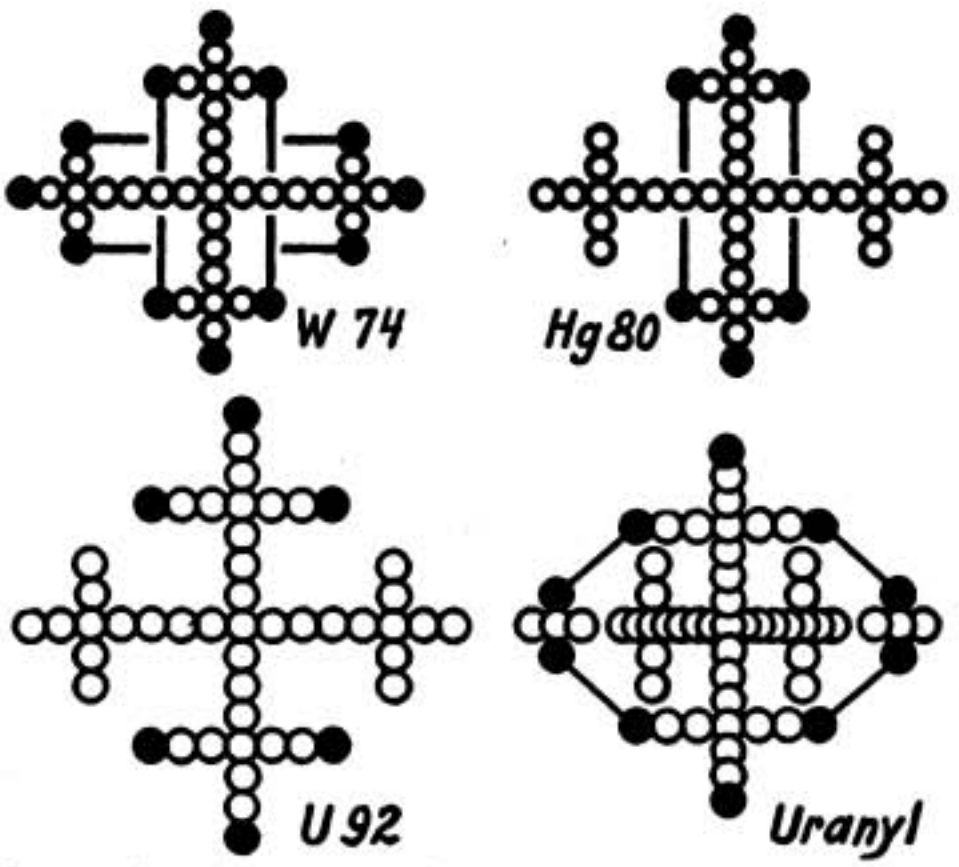

Fig. 43. Atomic structures of tungsten, mercury, and uranium.

chemical combination. After the central structure has become sufficiently built up, however, the hydrogen groups will no longer be within the zones of intense electrification, but will be free to combine with more than three valence bonds from other atoms. The appearance of tetravalent

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hafnium and pentavalent tantalum may be explained in this manner. On the other hand it is also possible that hafnium and tantalum may be the first two members of the tungsten-radon series as suggested by the diagrams in Fig. 42. A comparison of the spectra ought to be helpful in allocating these two elements.

If we start backwards from the radon atom by changing the peripheral helium groups successively into hydrogen groups, then the periphery will become entirely filled with hydrogen groups when we arrive at tungsten. This would satisfactorily account for the physical and chemical properties of tungsten, and especially for its high melting point.

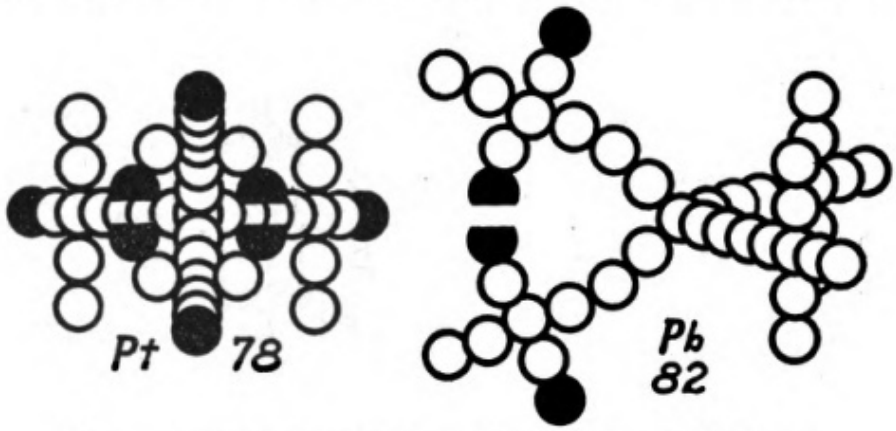

Fig. 44. Three-dimensional views of the platinum and lead atoms.

The platinum atom in Fig. 44 is shown with a valence of four, but the uppermost and lowermost hydrogen groups may combine with each other so as to leave the atom with a valence of two. If one of the rear hydrogen groups is substituted by a helium group the gold atom is produced, whereas if both are substituted by helium groups the mercury atom is produced. It appears that in the mercury atom a branched valence bond may be formed by the union of the uppermost and lowermost hydrogen groups so to produce univalent mercury, whereas if these two hydrogen groups remain free the atom is divalent. In metallic mercury all hydrogen groups are probably combined with each other in

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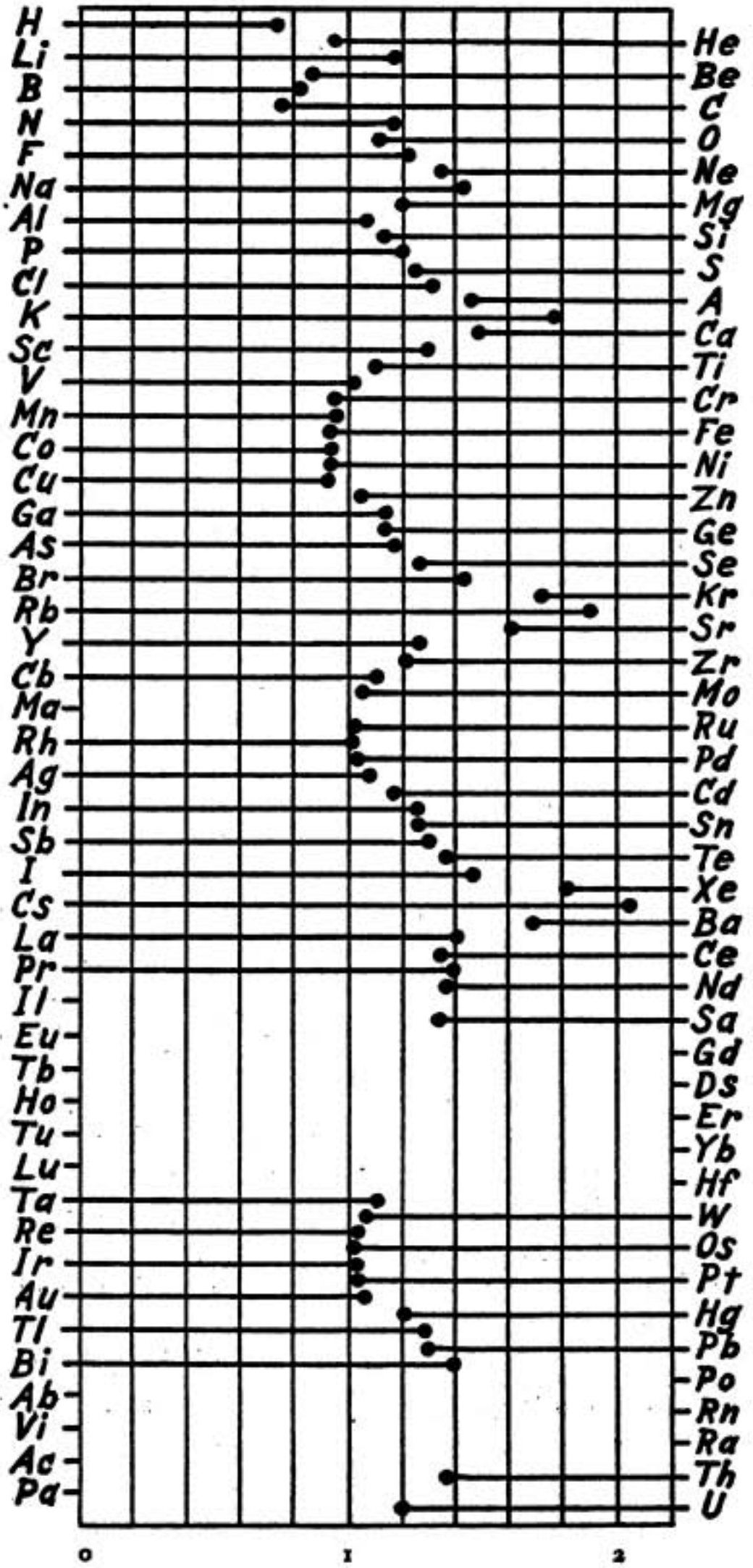

Fig. 45. Atomic radii. All values except those of hydrogen and helium were calculated from the densities of the elementary substances in the solid state.

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pairs, which would account for the low melting point of mercury as compared with elements like lead in which at least two of the hydrogen groups are always prevented by the adjacent inert structures from combining with each other.

Most of these atomic structures had to be arrived at by interpolation and are still in the speculative stage, but experimental proofs or disproofs will undoubtedly be forthcoming in the future. A study of the atomic spectra from the standpoint of the vortex atom theory should be of value here, and X-ray diffraction studies of crystals should give valuable information as to the shapes and dimensions of the various atoms. For example, the iodine atom under the vortex theory is about three times as long as it is wide, whereas the nucleated iodine atom should measure about the same in all directions. An examination of crystalline iodides by the X-ray diffraction methods now in use should be sufficient to decide between these two structures.

Fig. 45 shows that the atoms of the heavier elements are only slightly larger than the atoms of the lighter elements. If the atoms were constituted exactly as shown in the diagrams, then the differences in size should be much greater than is actually the case. On the other hand if we assume that the elementary vortex rings in the heavier elements are smaller than in the lighter elements, then we would have difficulty in explaining why the individual protons in the heavier elements have very nearly the same mass as in the lighter elements. The only remaining possibility is that the protons, electrons, and neutrons in the heavier elements are crowded more closely together than in the lighter elements. This explanation seems reasonable when it is considered that the different parts of an atom are probably held together by push or pressure from the outside rather than by pull or tension from the inside. Since the heavier atoms have more vortex rings exposed to external ether currents than the lighter elements, it may be presumed that they are under more pressure from the outside.

Under the vortex theory radioactivity and the splitting of the uranium atom are peripheral acitivities. The uranium

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atom has the same general structure as the barium atom except that branched clusters of valence bonds take the places of the single valence bonds of the barium atom. When a uranium atom (especially the uranium isotope 235) is bombarded with neutrons, some of them will become attached to the periphery of the atom so that the periphery will become more crowded and will tend to expand. Such expansion is prevented only by the four radial arms of the central helium group, and when these arms tear, the atom flies to pieces. The products of such disintegration consist of two separate and distinct series of elements, namely Br, Kr, Rb, Sr, Y, Zr, Cb, and Mo, (all of which have two structural centers), and Sn, Sb, Te, I, Xe, Cs, Ba, and La, (all of which have three structural centers with four helium groups between adjacent centers). The elements Ru, Rh, Pd, Ag, Cd, and In have never been found among the uranium split products, although they are the very ones that we would expect to find if the uranium atom would divide into two approximately equal parts. (*NATURW.*, Aug. 23, 1940, p. 543.) It will be noticed that each of these intermediate elements has only three helium groups between at least some of its structural centers. If we assume that it is always the shorter arms of the uranium atom which tear off, then the absence of these intermediate elements would be accounted for. On the other hand with such an assumption we would have difficulty in accounting for the presence of the elements Sn to La, unless we assume that the neutrons convert some of the terminal helium groups into hydrogen groups.

Ordinary radioactivity consists of the emission of alpha or beta particles, often accompanied by gamma radiation. The alpha and beta particles may be formed *de novo* at the instant of emission, instead of existing preformed within the atoms as is generally assumed. It is readily conceivable that an alpha particle could be formed whenever four neutrons are brought into close proximity with one another. If two of the neutrons arrange themselves with their negative ends inwardly, and the other two with their positive ends inward-

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ly, then all the essential parts of an alpha particle will be present. The two neutrons which have their positive ends positioned inwardly may then be assumed to shed their outer vortex rings so as to be changed into ordinary protons. It does not seem possible that alpha particles can always be formed by the simple separation of terminal helium groups because this would not account for the conversion of uranium into radium and the latter into radon with a total loss of six valence bonds.

The formation of negative electrons *de novo* during beta particle emission would also make it easier to explain the radioactivity of tritium which has a half life period of thirty years and is transformed into hybridium (the so-called "helium isotope") with the emission of a negative electron of about 15 kev. (*PHYS. REV. 58,* 574, 1940.) If we assume that the triton consists of three protons in axial alinement with one another, then it is conceivable that single vortex rings (probably from cosmic radiation) may loosely attach themselves to the two outermost protons, and then combine with each other so as to form a beta particle.

The theory that beta particles may be produced *de novo* by the combination of two single vortex rings will also help to explain the production of electron pairs (electrons and positrons) during artificial radioactivity. For example, it is conceivable that when a certain helium group carries on each side thereof a captured electron as shown in Fig. 20, and one of these captured electrons is struck by a neutron, then the impacted electron will swing around and collide with the other captured electron with sufficient violence to cause the four vortex rings to rearrange themselves in such a manner as to produce an electron pair, while the neutron attaches itself in place of the impacted electron.

Whether or not the radioactive displacement law is entirely correct will have to be left for future decision. This law was based on the nuclear theory of the atom, and if the nuclear theory is itself erroneous, then the radioactive displacement law will probably also need revision. But even if the radioactive displacement law is entirely correct, the

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formation of an additional hydrogen group or the conversion of a hydrogen group into a helium group can be explained under the vortex theory if we assume that under certain conditions a neutron may be transferred from one atomic branch to another with the simultaneous displacement of a negative electron.

TABLE IV

Melting Points

(Generally increasing from left to right)

He −272	Li 186	Be 1280	B 2300		C 4000	●●●●
Ne −249	Na 98	Mg 651	Al 659		Si 1420	●●●●
A −189	K 62	Ca 851	Sc 1200		Ti 1800	
			V 1710	Cr 1615	Mn 1260	Fe 1533 ■→
Kr −157	Rb 39	Sr 771	Y 1490	Zr 1700	Cb 1950	Mo 2620
Xe −140	Cs 28	Ba 704	(R.E.)	Hf 1700	Ta 2850	W 3370 ■→
Rn −71	Vi	Ra 960	Ac	Th 1845	Pa	U 1750

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TABLE V

Melting Points

(Generally decreasing from left to right)

••••								N −210	O −218	F −223	Ne −249
••••								P 44	S 113	Cl −101	A −189
➡	Fe 1533	Co 1480	Ni 1452	Cu 1083	Zn 419	Ga 30	Ge 958	As 815	Se 220	Br −7	Kr −157
Ma	Ru 2450	Rh 1955	Pd 1555	Ag 961	Cd 321	In 155	Sn 232	Sb 631	Te 453	I 144	Xe −140
➡	W 3370										
	Re 3000										
	Os 2700										
	Ir 2450										
	Pt 1755										
	Au 1063	Hg −39	Tl 304	Pb 327	Bi 271	Po <1800	Ab	Rn −71			

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TABLE VI

The Elements and Their Isotopes

\+ 5% to 20% ++ More than 20% * Radioactive

1.5 Hy ++3	1 H, D, T ++1 2 3*						2 He ++4
3 Li +6 ++7	4 Be 8? ++9 10?	5 B +10 ++11	6 C ++12 13	7 N ++14 15	8 O ++16 17 18	9 F ++19	10 Ne ++20 21 +22
11 Na ++23	12 Mg ++24 +25 +26	13 Al ++27	14 Si ++28 +29 30	15 P ++31	16 S ++32 33 34 36	17 Cl ++35 ..... ++37	18 A 36 ..... 38 ..... ++40
19 K ++39 40* +41	20 Ca ++40 ..... 42 43 44 ..... 46 48	21 Sc ++45	22 Ti +46 +47 ++48 +49 +50				
23 V ++51	24 Cr 50 ..... ++52 +53 54	25 Mn ++55	26 Fe +54 ..... ++56 57 58	27 Co 57 ..... ++59	28 Ni ++58 ..... ++60 61 62 64	29 Cu ++63 ..... ++65	30 Zn ++64 ..... ++66 67 +68 70
	31 Ga ++69 ..... ++71	32 Ge ++70 ..... ++72 +73 ++74 ..... +76	33 As ++75	34 Se 74 ..... +76 +77 ++78 ..... ++80 ..... +82	35 Br ++79 ..... ++81	36 Kr 78 ..... 80 ..... +82 +83 ++84 ..... +86	

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(TABLE VI (Continued)

37 Rb	38 Sr	39 Y	40 Zr	41 Cb	42 Mo
					+92
			++90		.....
	84		+91		+94
++85	.....		++92		+95
.....	+86	++89	.....	++93	+96
++87*	+87		+94		+97
	++88		.....		++98
			96		.....
					+100

43 Ma	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd
					106
	+96		102		.....
	.....		.....		108
	98?		+104		.....
	+99	101	++105	++107	+110
	+100	.....	++106	.....	+111
	++101	++103	.....	++109	++112
	++102		++108		+113
	.....		.....		++114
	+104		+110		.....
					+116
					118?

49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
	112				124
	.....		120		.....
	114		.....		126
	115		122		.....
	+116		123		128
113	+117	++121	124		++129
.....	++118	.....	+125	++127	130
++115	+119	++123	+126		++131
	++120		.....		++132
	.....		++128		.....
	+122		.....		+134
	.....		++130		.....
	+124				+136

55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Il
	130				++142	
	.....		136		+143	
	132		.....		++144	
	.....		138		+145	
++133	134	++139	.....	++141	+146	
	+135		++140		.....	
	+136		.....		+148	
	+137		+142		.....	
	++138				+150	

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(TABLE VI (Continued)

62 Sa	63 Eu	64 Gd	65 Tb	66 Ds	67 Ho
144					
.....		152			
.....		.....		158	
+147		154		.....	
+148*	++151	++155		160	
+149	.....	++156	++159	++161	++165
+150	++153	+157		++162	
.....		++158		++163	
++152		.....		++164	
.....		160			
+154					

68 Er	69 Tu	70 Yb	71 Lu	72 Hf	73 Ta
162		168		172?	
.....		.....		.....	
164		170		174	
.....		+171	++175	.....	
++166	++169	++172	176*	+176	++181
++167		+173		+177	
++168		++174		++178	
.....		.....		+179	
+170		+176		++180	

74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au
		184			
180		.....		192	
.....		186		.....	
++182	++185	187	++191	++194	*
+183	.....	+188	.....	++195	++197
++184	++187	+189	++193	++196	
.....		++190		.....	
++186		.....		+198	
		++192			

80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 Ab	86 Rn
196						
.....						
+198		204				
+199	++203	.....				
++200	.....	++206	++209			
+201	++205	++207				
++202		++208				
.....						
+204						

87 Vi	88 Ra	89 Ac	90 Th	91 Pa	92 U
					234*
					235*
			++232*	++231*	.....
					.....
					++238*

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Living Matter

THE present chapter does not purport to be a treatise on biochemistry, but rather a general consideration of living matter from a theoretical or philosophical standpoint. There has been some some dispute as to whether the expression "living matter" is justifiable, life processes being usually associated with definite physical organizations and not merely with the presence of a certain kind of substance. Physical organization disappears, however, in the direction of the simpler forms of life, and in the case of filtrable viruses is entirely absent or is on so small a scale as to be hardly distinguishable from the chemical organization of the larger organic molecules. It is in the region of about 50 Angstroms where chemical and biological structures merge into each other. Any physical structures as small as 50 Angstroms must be extremely simple, and it must obviously be the chemical rather than the physical behavior of such structures which determines whether they are living or non-living.

If life in its simplest form is essentially a chemical process, then it must be the function of a definite kind of substance, which can only be of a proteinaceous character. Carbohydrates serve merely as structural material, or when present as sugars may furnish energy upon oxidation. Fats and substances normally present in the dissolved or molecular state may serve various subsidiary purposes, but unless they are so constituted as to be able to polymerize or condense from dilute solutions in such a manner as to perpetuate definite patterns, they could not be considered as an essential part of living matter. It is by such a process of elimination that we eventually arrive at the conclusion that living matter must be some material of a proteinaceous character, built up of alpha amino acid residues.

Proteins differ from most other chemical compounds in that it is not possible to represent them by any simple em-

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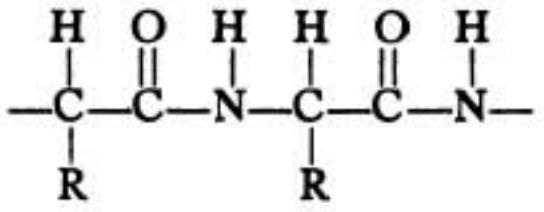
pirical formula. Their composition is generally somewhat as follows: C 40—55%, H 6.8—7.0%, N 16—18%, O 20—23%, S 0.5—2.5%, P 0.5—1.5%. The per-cent of hydrogen is somewhat indefinite because of the difficulty of removing all the water, and this also renders the per-cent of oxygen indefinite. The per-cent of carbon depends in part on the number and sizes of the hydrocarbon side-chains, on which the per-cent of hydrogen also depends. The per-cent of nitrogen, however, is of greater significance, there being reasons for believing that the large majority of the nitrogen atoms occupy just one unique position with respect to the surrounding structure, namely as parts of polypeptide chains. The number of oxygen atoms is about one-fifth greater than the number of nitrogen atoms, due no doubt to the presence of hydroxyl groups on some of the hydrocarbon side-chains. The sulphur and phosphorus atoms are present in much smaller numbers than the nitrogen atoms, hence sulphur and phosphorus cannot form regular building blocks in the polypeptide chains. This conclusion is also corroborated by the fact that sulphur and phosphorus can be readily removed from proteins by treatment with hot alkali.

The theory that proteins consist essentially of long polypeptide chains built up of amino acid residues so as to form the sequence:



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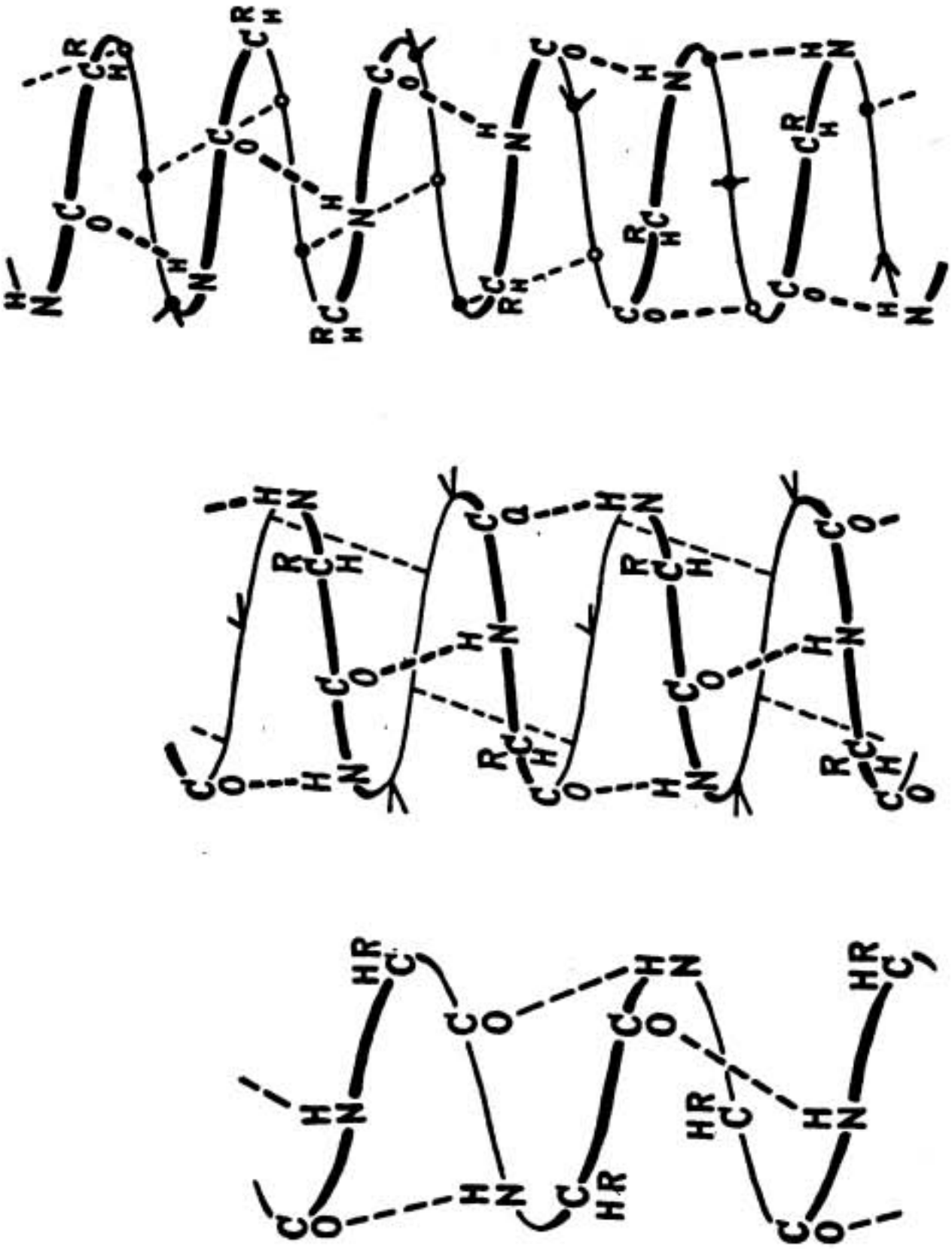

Fig. 46. Polypeptide spirals.

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has been advanced long ago by Emil Fischer, but the question as to how these chains could be arranged in space so as to form at least a working model of living matter had remained unanswered until 1927 when their arrangement in the form of parallel spirals was suggested. (C. F. Krafft, *Spiral Molecular Structures, the Basis of Life.*) These spirals may be presumed to grow endwise by the addition of amino acid residues, always maintaining the same cross-sectional pattern. Since there is no limit to the complexity of the pattern which could be thus perpetuated, we have here for the first time a mechanical model by which the process of heredity can be represented as a function of a physical structure. This was expressed in the writer's 1927 monograph in the following words:

> The smallest baoillus . . . consists of a large number of such spirals in parallel formation. . . . The arrangement and spacing of the different spirals must necessarily be maintained throughout growth, and will, upon division, be transmitted to the progeny by a process of heredity.

Besides accounting for growth and heredity, the spiral polypeptide theory also accounts for the optical activity of amino acids obtained by hydrolytic decomposition of proteins. A mere zigzag folding of the polypeptide chains as taught by W. T. Astbury would not account for such optical activity. It may be true, as Astbury contends, that his folded structures can be built up of optically active amino acids, but unlike the spiral structures, they can also be formed equally well with racemic mixtures.

In 1927 when the spiral protein theory was first suggested, it was the prevailing opinion that proteins were complex, almost beyond comprehension. The suggestion that they may have a comparatively simple internal structure with their main-chains parallel to one another did not meet with much favor, but a few years later the examination of proteins by X-ray diffraction methods showed that they actually do have such a structure.

Polypeptide spirals may assume many different forms, a

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few of the forms most likely to occur in proteins being shown in Fig. 46. These may be joined laterally to one another through their side chains or through hydrogen bonds or disulphide links so as to form honeycombed structures with cross-sectional patterns of any form. Such structures are ideally suitable as models of living matter because the large open spaces would be filled with nutrient solution, and as the structures are not chemically symmetrical in their longitudinal directions, they would tend to keep the nutrient material in their interstices moving in one direction, especially if exothermic processes of oxidation take place so as to cause pulsations or other rhythmic movements of the spirals.

Although the physico-chemical complexity of the higher forms of life may be almost beyond comprehension, nevertheless after life processes in their simplest form have been accounted for, the difficulty in understanding or explaining the more complex forms of life is largely one of detail rather than one of principle. There are two types of scientific mysteries. One type is characterized by our ignorance of facts. Thus the topography of the opposite side of the moon is a scientific mystery, not because we are unable to suggest plausible hypotheses, but because we do not know the facts and details. Life processes, however, have constituted a different kind of scientific mystery. In our effort to explain a process like heredity our main difficulty has not been mere ignorance of details, but rather our inability to suggest any plausible hypothesis or working model. Facts and details we had in abundance, but the problem of visualizing how a complex structure could reproduce itself has heretofore baffled our understanding.

With our present knowledge of protein chemical structure, the most serious part of the difficulty has been eliminated. On the basis of such a structure we are now able to suggest how a pattern of unlimited complexity can be duplicated and distributed among the progeny. The "pattern" here referred to exists only in the germ plasm, and while its primary function is to perpetuate itself, it is conceivable that it may divide in such a manner that one of the daughter structures

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suffers a slight change of pattern at the instant of division so that only the other daughter structure will be able to perpetuate the original pattern. The structure with the altered pattern may then continue to grow and perpetuate its modified pattern until some later time when still another modification may occur, and in this manner produce one tissue after another until the complete body of the adult individual is formed.

Although this is admittedly a very general and extremely vague explanation, nevertheless it does show that with our present understanding of protein structure the problem of explaining life processes is no longer as difficult as it formerly was. If instead of devoting only a few pages to this subject we would devote several hundred thereto, and correlate our explanation with the innumerable known facts of biochemistry and cytology, it should be possible to explain the processes of growth and heredity in sufficient detail to convince even the most skeptical individuals that the physico-chemical explanation of life processes can hardly be said any longer to baffle the understanding.

Our study of ether and matter would not be complete if we were to confine ourselves to the physical or mechanical aspects of the subject, without any consideration of its metaphysical aspects. The existence of mind and consciousness cannot be denied, but opinions differ widely as to how they should be interpreted and allocated. It appears that all different views on this subject can be classified into two general groups. The older view, which is today accepted by at least nine people out of ten, and may therefore be called the "orthodox" view, is that mind and consciousness are indications of the existence of a soul or spiritual entity which exists *in addition to* the chemical elements C, H, N, O, S, P, etc. and structural organizations, although in close association therewith. On the other hand the view of the minority, which is also of more recent origin, is that there is no separate spiritual entity, and that mind or consciousness is merely the *subjective aspect* of the living organism. No other interpretation of mind or consciousness is possible. There either

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does, or does not exist a separate metaphysical entity. It is inconceivable how there could be any middle ground between these two alternatives.

If there does exist a separate metaphysical entity, then it must exist in space, because otherwise it would not be an "entity". Anything that is real but does not have spatial existence may be an attribute or aspect, but cannot be an entity. But if there does exist a separate metaphysical entity, then the space which it occupies could not be occupied by the ether, unless such entity is itself merely ether in motion. In either case it would have to occupy space to the exclusion of other things such as atoms and molecules which are known to exist in space, or if it consists of ether in motion on a larger scale, then it would have to coact with other physical forces which presumably also consist of ether in motion. In either case it seems that if mind or consciousness is a separate entity, then it should have been detected with scientific instruments long ago.

Concerning the prevalent misconception of the "mind" as a separate entity, Hugh Elliot states in his book on *Modern Science and Materialism* that

> We speak of the mind as though it were a thing, and since it is not a material thing, it is regarded as possessing a spiritual consistency. If we can, by a great effort, shake off this paralyzing prejudice —a prejudice which has been immensely fortified and refined by the whole Kantian philosophy—we may still preserve sufficient elasticity to perceive that we know of no such *thing* as mind; . . . (p. 121-122)

Belief in the existence of a separate metaphysical or spiritual entity is due in a large measure to our innate feeling that we possess freedom of will by virtue of which our choice of action is not necessitated but is voluntary. We must bear in mind, however, that the will is itself determined by physico-chemical activities in the brain and sympathetic nervous system of which we are not directly aware. "Human liberty, of which we all boast," said Spinoza,

> consists solely in this, that man is conscious of his will, but unconscious of the causes by which it is determined.

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Our will is merely our superficial awareness of the cerebral conditions which induce us to act, and is not itself the cause of our action. We have the feeling that our will is free because we are unconscious, or at least not completely conscious of the underlying physiological processes by which our will is determined. All discussion about "the freedom of the will" is eventually going to be abandoned because there is no such an entity as "the will", either free or determined.

On the other hand the interpretation of mind or consciousness as merely the subjective aspect of the living organism is often said to be confronted with difficulties when we try to explain how the complexity of human thoughts could be accounted for on such a basis, or why it is only the human or animal organism that possesses a subjective aspect in the nature of consciousness.

Those who attack this interpretation of mind or consciousness on the ground of insufficient complexity are usually physicists with no special training in biology or biochemistry. They think of discrete electrons and atoms when they ought to be thinking of organized neurones with their axones and synapses. They visualize the brain as "a maelstrom of scurrying atoms and electric charges" which "in obedience to the laws of physics have come together and built human brains" (A. S. Eddington, *Science and the Unseen World*, pp. 28 and 59), whereas they ought to visualize it as a highly organized biochemical system that has developed gradually after millions of years of evolution. They attempt to employ in biology a method of reasoning which always falls back on protons and electrons instead of on those highly complex chemical structures that occur in living matter. A logic which applies appropriately to single atoms may not apply at all to an organization of atoms and molecules—a biological system. It is as if a chemist kept harping on the elements hydrogen and oxygen with the implication that no such properties as we find in water could result from these two elements. Furthermore the first stage of organic

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evolution was not the coming together of electronic particles in obedience to the laws of physics to build human brains, but rather the coming together of organic molecules under the laws of chemistry to build primitive protoplasmic cells. No doubt the simple elementary laws of physics have played an important part in brain building, but there were also other laws such as those of organic chemistry, biology, genetic psychology, and social evolution, all of which have had their effect on brain development.

Even as early as 1861, E. Brücke clearly alluded to the physicochemical organization of the protoplasm when he told us that

> We must therefore ascribe to living cells, beyond the molecular structure of the organic compounds that they contain, still another structure of different type of complication; and it is this which we call by the name "organization." (*Elementarorganismen.*)

As to the difficulty of explaining why it is only the human or animal organism that possesses consciousness, the answer is that no such assumption is necessary. It is generally admitted that an animal possesses consciousness because of its physicochemical organization, but if organization gives rise to consciousness, then there should be consciousness wherever there is organization, or as stated by L. T. Troland:

> If unification of many components is required to yield consciousness, then we should expect to find consciousness wherever such unification exists. . .
>
> Something of the nature of consciousness is associated with all physical realities. . .
>
> For every relation between parts in the conscious structure there is a corresponding relation in the physical structure. (*The Mystery of Mind,* pp. 227, 232, and 235.)

Every elementary particle of matter must therefore possess a consciousness peculiar to itself and commensurate with its structural organization or unification. Since the specific structures of atomic particles and of human beings are entirely different, their types of consciousness must also

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be entirely different, which Troland has aptly expressed as follows:

> Nearly all the non-human sentiencies differ from any form of human consciousness as much as the most widely different of such forms differ from each other. (p. 245)

This panpsychic doctrine, in conjunction with the ether vortex theory, throws open a large field for further study. According to this doctrine it must be in the ether where consciousness has its origin. The ether would then be the common substrate of both mind and matter, and by virtue of its subjective and objective aspects it would have psychical as well as physical attributes, both of which would be governed by similar or analogous laws and principles. Thus in physics we have the forces of repulsion and attraction which are closely related to the psychological states of pain and pleasure. Repulsive forces tend to weaken themselves whereas attractive forces tend to strengthen themselves—a relationship closely parallel to one's response to pain and pleasure.

Unity of consciousness may have its basis in some unique form of motion of the ether in the central nervous system, or it may be merely the result of the peculiar chemical organization that exists in living matter. If the atoms of matter consist of vortex formations in the ether, then these two interpretations of consciousness would have the same meaning, because under the vortex theory organized chemical structures themselves consist of unique forms of motion in the ether.

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